Research on the Environmental Conditions of Ground and Surface Water Prevailing in the Training Area at CFB Gagetown, New Brunswick – Part II

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Chart held at DRDKIM

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Abstract

The work contained in this report is a follow-up and confirmation of the data collected during Part I of this campaign in 2001. Part I involved the sampling of 42 wells in the northern half of CFB Gagetown to characterize the underlying groundwater flow dynamics as well as the chemical characterization of the groundwater quality. This early work, which is to be found in DRDC Valcartier technical report TR 2003-016, identified a possible low-level contamination of some areas of CFB Gagetown by energetic materials. As well, seven elements in thirty-two wells were found to be higher than specified in the Canadian Council of Ministers of the Environment (CCME) guidelines.

Part II of this campaign was performed in October 2002 at CFB Gagetown, and is the focus of this report. Eighteen monitoring wells were installed, developed and sampled during Part II, largely in the southern area of the Base. In addition, 33 of the wells installed during Part I were re-sampled, and fourteen bivouac wells sampled. The data collected was used to confirm and expand the piezometric map of the aquifer underlying the Base, and to confirm and expand the analytical results of Part I.

Aluminium, manganese and iron were again found in concentrations above the CCME guidelines, confirming the findings of Part I. However, energetic materials were not detected in any of the ground or surface water samples, contrary to results from Part I. Perchlorates, which have been detected in the groundwater on American Bases, were strategically sampled in a small number of wells. Perchlorates were not detected above the detection limit of the analytical method used (500 ppb).

Résumé

Le contenu de ce rapport est le suivi et la confirmation de l'information amassée pendant la Phase I de la campagne en 2001. Au cours de la Phase I, 42 puits ont été échantillonnés dans la région nord de BFC Gagetown dans le but de caractériser l'écoulement et la composition chimique de l'eau souterraine. Ce travail, qui se trouve décrit dans le rapport technique TR 2003-016 de RDDC Valcartier, a permis d'identifier la possibilité de contamination par les matériaux énergétiques à quelques endroits de la BFC Gagetown. De plus, sept éléments dans 32 puits ont été détectés dans des concentrations supérieures aux niveaux suggérés par le Conseil canadien des ministres de l'environnement (CCME).

La Phase II de caractérisation de la BFC Gagetown a été effectuée en octobre 2002, et cette Phase est le sujet de ce rapport. Dix-huit puits ont été installés, développés et échantillonnés pendant la Phase II. La majorité de ces puits se trouvent dans la région sud de la Base de Gagetown. De plus, 33 des puits installés pendant la Phase I ont été échantillonnés à nouveau et 14 des puits de bivouac ont été échantillonnés. L'information amassée pendant la Phase II était utilisée pour confirmer et agrandir la carte piézométrique de l'aquifère qui se trouve sous la Base et pour confirmer les résultats analytiques de la Phase I.

La pesée d'aluminium, de fer et de manganèse a été confirmée en concentrations au dessus des critères du CCME. Contrairement aux résultats de la Phase I, les matériaux énergétiques n'ont pas été détectés dans les eaux souterraines ni dans les eaux de surface. Le perchlorate, qui a été échantillonné d'une façon stratégique dans quelques puits, mais n'a pas été détecté au dessus de la limite de détection de la méthode analytique (500 ppb).

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Sommaire

L'entraînement militaire est essentiel pour maintenir l'efficacité des troupes, mais si l'entraînement a un effet négatif sur l'environnement, plusieurs restrictions seront mises en place. À la fin, ces restrictions vont avoir un impact important sur l'efficacité de l'entraînement, et par extension sur l'efficacité des troupes. En plus, un terrain d'entraînement qui est dégradé va fournir un entraînement moins réaliste. C'est difficile d'avoir le bon entraînement sur un terrain qui n'a plus de végétation et qui est sujet à l'érosion. Donc, c'est dans l'intérêt de l'armée de prendre soin de ses terrains d'entraînement.

Récemment, des problèmes ont été soulevés par la possibilité que les matériaux énergétiques soient libérés dans l'environnement par les munitions militaires qui n'explosent pas comme prévu à l'impact. Ces munitions peuvent théoriquement laisser s'échapper des explosifs. Les détonations partielles peuvent projeter un pourcentage de ces explosifs aux alentours immédiats de la munition. Les munitions qui ne détonnent pas (les UXO) peuvent être ouvertes par les autres munitions qui n'explosent pas comme prévu. Une autre possibilité est que les UXO soient sujets à la corrosion, et après plusieurs années, soient corrodés au point où les matériaux énergétiques peuvent sortir par des perforations.

Aux États-Unis, le RDX - un explosif militaire - a été trouvé dans l'eau souterraine de la Base Massachusetts Military Reserve (MMR), avec pour conséquence la fermeture de la Base par l'Agence de protection de l'environnement (EPA) en 1998. Un autre produit chimique, le perchlorate, qui se retrouve dans les fumigènes, les munitions éclairantes et le propergol dans les fusées. Ce produit a aussi été trouvé dans les eaux souterraines de différentes Bases américaines.

À RDDC Valcartier, on a entrepris un programme de R&D en collaboration avec des partenaires canadiens comme l'INRS-ETE et américains comme le Cold Regions Research and Engineering Laboratory (CRREL) au New Hampshire et le Waterways Experimental Station (WES) du Mississippi. Ce programme a pour but de mieux comprendre les effets environnementaux causés par les explosifs et autres contaminants issus des munitions, et de proposer des solutions ou des méthodes de mitigation de la contamination. Dans le contexte international de la démilitarisation, plusieurs Bases sont en voie d'être fermées. Cette situation, combinée aux aspects des lois environnementales de plus en plus sévères, a créé des nouvelles possibilités pour la recherche.

Plusieurs activités des Forces canadiennes, comme l'usage de munitions, la démolition et la destruction des munitions par la détonation ou le brûlage, peuvent contaminer l'environnement avec des explosifs. La recherche sur la caractérisation de cette contamination va donner au MDN la capacité de mieux comprendre les impacts environnementaux de l'entraînement de tir réel et par extension d'être prêt à répondre aux questions soulevées et de prendre ces actions correctives si nécessaires.

Suite au travail effectué à BFC Shilo, Gagetown a été choisi comme second lieu d'étude étant donné l'usage intensif des terrains d'entraînement, et son contexte géologique.

La première Phase de l'étude fut réalisée en octobre 2001. Le travail discuté dans ce rapport concerne la Phase II, qui a été effectuée en octobre 2002.

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Executive summary

Realistic training is essential to maintain troop readiness. However, if training practices have a negative impact on the environment, increased restrictions will eventually have to be placed on critical training. It is in the army's best interest to take environmental care of the training lands it currently possesses, as it will likely be using the same training areas for decades to come. Besides the possibility of restrictions on training, an environmentally degraded area will provide less-realistic training as well. "Train as you fight" has long been an unofficial motto of the armed forces, but it is difficult to train properly in an area devoid of vegetation and subject to large-scale erosion due to poor environmental practices.

Recently, concerns have been raised by the possibility of energetic materials being released into the environment by munitions used in training. Live munitions containing high explosives can release their explosive fillings into the surroundings through a number of different theoretical routes. Unexploded duds may sit for decades under the surface, slowly corroding until the explosives inside finally escape. Partial detonations ("low-orders") may spray a percentage of their explosives into the environment. Small rounds may detonate poorly because of their size, leading to the same result. Rocket propellants, smoke and illumination rounds contain perchlorates. Many of these chemicals have been found in the ground water near the Massachusetts Military Reserve (MMR) on Cape Cod, which lead to its closure in 1998 by the Environmental Protection Agency.

At DRDC Valcartier an R&D program was initiated in collaboration with various partners including INRS Géoressources and US Army R&D centers such as Cold Regions Research and Engineering Laboratory (CRREL) from Hanover and the Waterways Experimental Station (WES) from Mississippi. The program is designed to better understand the complex fate of explosives and other co-contaminants in soils and ground water and to propose solutions or mitigation methods whenever appropriate. The international context of demilitarization, the closure of military Bases and the more stringent aspects of environmental law, have led to the establishment of areas for research and development. Many activities of the Canadian Forces such as the firing of ammunition, demolitions, and the destruction of obsolete ammunition by open burning and open detonation may lead to the dispersion of energetic compounds in the environment. The program on training range research characterization allows the DND to better understand the impacts of live fire training and therefore to be in a state of readiness to answer any inquiries and take corrective actions if needed. After previous work at CFB Shilo, the CFB Gagetown training area was selected in priority for this project Based on its intensive use by the Canadian Forces and allied troops and Based on its particular geographical and geological context.

The first Phase of the study occurred in October 2001 and focused on groundwater and surface water. The work reported in this report represents the second Phase of the study, conducted in October 2002. Together, the two reports address the question of whether military training at Gagetown is having an impact on the quality of the groundwater.

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Acknowledgements

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1. Introduction

1.1 Background

Sustainable training in the context of military activities has only been an issue since the early 1990s. Increasing pressure from the government and environmentalists, calling for improved transparency of how military activities are impacting the environment on and around Bases and training areas has caused significant changes in how the military manages its training lands. In the United States, the new army slogan is "Protecting the Environment and our Country". This focuses on the fact that army training areas are the only large non-developed tracts of land in several regions.

To date, the most serious known case of environmental contamination caused by military training remains the Massachusetts Military Reservation (MMR). The MMR encompasses nearly 14000 acres of land on Cape Cod, not far from Boston. In 1998, RDX – a military explosive – was detected in the Cape Cod Aquifer, which serves the drinking water needs of much of Cape Cod. The source of this RDX was the training areas of the MMR, and as a consequence the U.S. Environmental Protection Agency shut the Base down.

The Canadian military manages and controls 18000 square kilometres of land - nearly three times as much territory as Prince Edward Island. Recently, public attention has been drawn to the environmental track record of the Department of National Defence with the 2003 Auditor General's report. In this report, which covers all aspects of governmental performance, one of the seven chapters was entitled Environmental Stewardship of Military Training and Test Areas. In this chapter, CFB Gagetown was identified as demonstrating a lack of due diligence with respect to its combat training area.

While the United States military has implemented a wide-ranging research program to better understand the environmental impacts of military training in the wake of MMR, several of the most comprehensive Base environmental assessments have been performed in Canada. Canadian Forces Base (CFB) Shilo in Manitoba was thoroughly studied by DRDC-Valcartier from 2000 to 2002. The assessment included a comprehensive evaluation of the groundwater as well as surface water, soils and biomass. With the experience gained through this study, a similar program was initiated in 2001 for CFB Gagetown. The first Phase of the study focused on the groundwater conditions in the northern area of the Base, and was reported in DRDC Valcartier technical report TR 2003-016. The second Phase of the study was performed in October 2002, and included both hydrogeological and surface sampling. This report concerns the hydrogeological findings, and as a result it is a continuation and expansion upon of the Phase I findings

2. Range history/description

This chapter has been updated from the Phase I report, and is provided for the convenience of the reader.

2.1 Geographical location

CFB Gagetown is located 20 km south-east of Fredericton, New Brunswick, in the county of Queens and Sunbury (Figure 1). The Base covers an approximate area of 1100 square kilometres. The training area can be divided into two physiographic regions, the New Brunswick Lowlands in the north and the Ste-Croix Highlands in the south. The northern half of the territory is generally used by the military as the Static Range Impact Areas (SRIAs), and the southern half of the Base as a General Manoeuvre Area, Dismounted Manoeuvre Areas, and the Mountain Impact Area. The Garrison is located in the northwestern portion of the Base, near Oromocto. Map 1 attached to this report shows a 1/200000 map of CFB Gagetown, indicating impact areas, manoeuvre areas, administrative areas, and the study area limits.

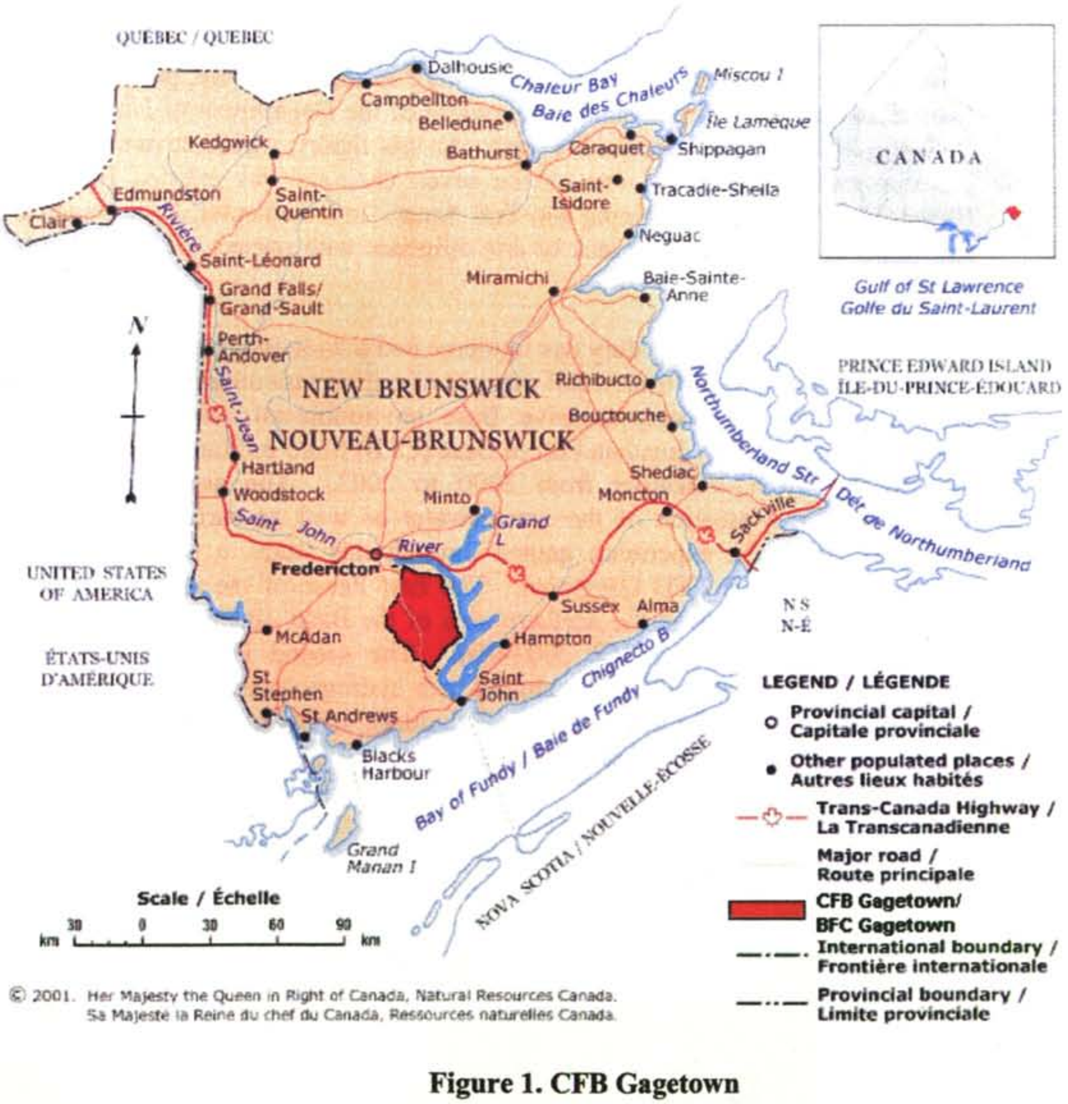

Figure 1. CFB Gagetown

2.2 History of activities

The first army training activities at CFB Gagetown took place in 1954. The Base has grown in importance since the mid 1990s with the closure of many Canadian Forces army Bases including Calgary, Chilliwack, and Shearwater. With these closures Gagetown became one of the four principal Bases left in Canada, along with Edmonton, Petawawa and Valcartier. Gagetown is the primary training Base for the Canadian Army. All of the combat arms have their national training schools in Gagetown, including the infantry, armour, artillery and the engineers. In addition, it is home to several regular force units, including 2nd Battalion, Royal Canadian Regiment, 4 Air Defence Regiment, 4 Engineer Support Regiment, and the 403 Tactical Helicopter Squadron. As well, almost all 25 reserve army units in Land Forces Atlantic Area (LFAA) use CFB Gagetown as a principal training site. The summer training period represents the highest tempo of training activities, with dozens of land force occupational courses taking place on its training areas.

As a result, CFB Gagetown is one of the most heavily used land forces Bases in Canada. The training activities associated with such use represent potential contamination sources when live or blank ammunition is used. .

2.3 Surficial geology

Surficial geological surveys as well as lithological data compiled from various boreholes carried out in 2001 and 2002 (Malcolm, 2003; Shaun, 2001) show that the Quaternary sediment cover of the Gagetown Base is generally quite thin and fairly uniform.

Surficial sediments consist predominantly of glacial sediments, mainly till, directly overlying bedrock. One of the main characteristics of tills in the region is that their grain size composition is largely controlled by the nature of the underlying bedrock. Till thickness varies significantly within the study area, being generally thin and discontinuous in the hilly Silurian-Devonian terrains of the southern part of the Base; in this region where areas shown as bedrock in Map 2 are generally covered by thin glacial sediments, the till matrix is generally greyish, moderately compact and sandy. The grain size composition of this till is highly variable (21-37 % sand, 27-45 % silt, 32-40 % clay), with a clast content varying between 17 and 34%.

In the gently rolling Pennsylvanian terrains of the northern part of the region, the till is moderately thick (1 to 6 m) and continuous and its matrix is typically very compact, reddish-brown and silt-rich. Its grain size composition is much less variable (30 % sand, 29% silt, 32-41 % clay), with a clast content varying between 14 and 19 %. However this till has a distinctly coarser matrix (54 % sand, 26 % silt, 20 % clay) and contains up to 40 % gravel in areas where it overlies conglomeratic bedrock.

These ubiquitous basal tills are characterized by low permeability, particularly those underlying the northern part of the Base, while the loose and sandier ablation tills overlying this till in some northern areas where they locally reach 10 m in thickness are much more permeable.

Other types of surficial sediments (glaciofluvial, marine and alluvial) locally overlie these glacial sediments in small areas of the Base, mainly valley floors, particularly that of the Nerepis River valley. In the latter, sandy blankets of deltaic and alluvial origin locally overlie marine fine-grained sediments, mainly silt. Since the postglacial marine incursion reached an elevation of about 60 m, similar sequences underlie valleys adjacent to CFB Gagetown, such as the Oromocto River and the St. John River valleys. In the northeast corner of the Base, near Swan Creek Lake, a thin cover of sandy beach sediments overlies the regional till sheet. Lastly, minor depressions on the Base are covered by peatlands where organic sedimentation continues to take place.

The total thickness of Quaternary sediments observed during our mapping surveys or by drilling during the two Phases varies from 1 to 22 m with a mean value of 4.7 m. Of course, these observed thicknesses do not apply to the St-John River valley that is underlain by a much thicker infill of Quaternary sediments.

2.4 Bedrock geology

The study area corresponds to the entire area of CFB Gagetown. CFB Gagetown is part of the Appalachian physiographic region and geologic province. The northern half of the Base is almost entirely underlain by a thick, monoclinal succession of clastic sedimentary rocks of the Pennsylvanian Cumberland Group; these poorly consolidated rocks are shown as Unit 3 on Map 3 attached to this report. These shallow-dipping strata are underlain by evaporitic and clastic rocks of the Mississipian Windsor Group, which outcrop as a narrow belt (Unit 2 on Map 3) crossing the central part of the Base. The southern half is underlain by a Basement complex of Silurian-Devonian age (shown as Unit 1 on Map 3); the steeply dipping, folded Silurian strata are composed mainly of clastic sedimentary rocks and locally intruded by Devonian granites and granodiorites. The northern part, including the Static Range Impact Area, consists of a northward-dipping cover of red to grey sandstone, conglomerate and siltstone of Pennsylvanian age (280-320 Ma).

2.5 Information sources

Part of the information needed to support the writing of this report was taken from Washburn and Gillis Associated Ltd. 1993/94 and from the topographic map of the CFB Gagetown Training Area (MCE 24 TR 84 ed 13). Some local hydrogeological characteristics were also found in Dames & Moores (1993), but the large majority of information used to develop the hydrogeological model and maps was drawn from field data obtained during Phases I and II of this study. The overview of the sensitive areas was also made possible with information and area map from the preliminary initial study. Field work and planning of related activities was authorized by M. Sheldon Downe, Land Forces Atlantic Area Environment Officer for CFB Gagetown.

3. Methodology

3.1 General

Field work for Phase II was conducted in October and November 2002. Eighteen new monitoring wells were drilled, developed, sampled and measured. The new wells were located on or around the impact areas of CFB Gagetown, in regions not covered or insufficiently covered by Phase I. The focus of Phase II was to obtain groundwater data from the southern half of the Base, as Phase I had concentrated on the northern portion of the training area. Established bivouac sites in the south of the Base had previously existing wells, and these were also sampled. Fourteen bivouac wells were sampled in total, with ten of them being in the southern half of the Base.

In addition, thirty-three of the thirty-five monitoring wells installed in 2001 for Phase I were measured, purged and sampled. This provided us the opportunity to confirm the results of Phase I and provided an insight into the potential variation of measurements from year-to-year.

All groundwater samples were analyzed for general chemistry, metals, and explosives. As well, nine samples were analyzed for perchlorates. In total, 244 groundwater and surface water samples were taken and analyzed (including duplicates and blanks). On-site piezometric measurements were performed prior to well purging to establish the height of the water table. As well, on-site physicochemical measurements were taken following purging and sampling of each well.

Prior to the installation of new wells, contractors using the EM-61 electromagnetic detector and a magnetometer proofed the drill site locations. This ensured that the drill teams would not hit buried ordnance. All well locations sampled in this Phase of the study are shown in Map 4 attached to this report.

3.2 Unexploded ordnance (UXO) proofing

UXO proofing consists of electromagnetic surveying the ground to detect surface laid and buried metallic objects, thus ensuring the absence of UXO. Clearance was conducted at all well locations by Dillon prior to drilling, to ensure the safety of drilling and technical personnel. The Dillon personnel along with Range Control and INRS personnel first used a GPS to locate and identify drilling sites. Following this, a 10 m rectangle area was swept with an electromagnetometer, and then repeated using a magnetometer (EM-61). Cleared locations were identified with red ribbon and staked indicating the date and drilling site number.

3.3 Borehole drilling & installation

The drilling and the installation of groundwater monitoring wells were conducted between October 1 and 9, 2002. Eighteen (18) wells were drilled and installed over the range (See Map 4 attached to this report). Well installation details of these wells are shown in Table 1. A complete survey summary may be found in Appendix A, on the CD-ROM attached to this report. All wells were installed using a Drilltec D25K air-rotary well drilling rig operated by Dayes Well Drilling. Well locations were selected according to the areas that were deemed best suited for the present investigation, in terms of their representative location, ease of access to the site in a safe manner and well positioning. All observation wells were to be drilled to at least 2 m below the water table.

The sediments encountered during drilling were observed, and soil and rock cutting samples were collected from the air-rotary holes, generally at 1.5 m intervals or at obvious changes in lithology. The compilation of all the well construction details is presented in Appendix A, on the CD ROM attached to this report.

Table 1 Well Installation Details

General				Well Details			Well Development and Yield		
Well Identification	Date Drilled	GPS Coordinates[1] Easting	GPS Coordinates[1] Northing	Total Depth (m)	Casing Depth[3] (m)	Casing Stick-up[4] (m)	Water Depth Below Grade (m)	Purged Volume[5] (L)	Total Estimated Yield[6] (igpm)
GW-DING-1	2/10/2002	711462.701	5075514.032	18.3	2.9	0.61	artesian	artesian	<0.5
GW-GAGE-2	1/10/2002	713592.646	5077145.613	18.3	3.7	0.60	3.40	---	4-5
GW-GREEN-1	1/10/2002	704595.073	5074180.063	18.3	7.4	0.39	6.27	675	2-3
GW-HERS-1	2/10/2002	710490.117	5072761.560	24.4	8.2	0.73	2.62	693	0.5
GW-HERS-2	2/10/2002	709012.498	5074430.712	30.5	2.7	0.61	19.05	350	<0.5
GW-MOUNT-2	3/10/2002	721964.623	5048500.034	18.3	2.9	0.43	0.60	520	6
GW-MOUNT-1	3/10/2002	722018.250	5049468.259	12.2	2.9	0.83	1.04	1388	1-1.5
GW-YORK-1	3/10/2002	718089.096	5048606.310	30.5	1.5	0.40	11.93	---	<1
GW-ENNI-1	4/10/2002	700515.629	5051054.082	18.3	1.5	0.42	6.75	675	2
GW-ENNI-2	4/10/2002	698979.572	5048085.921	24.4	10.4	0.72	0.27	403	2
GW-OPA	4/10/2002	702683.462	5068613.554	30.5	9.4	0.89	8.45	330	<0.5
GW-BROWN-1	9/10/2002	718075.840	5062743.224	30.5	9.4	0.76	21.09	---	<1
GW-GAGE-1	9/10/2002	716100.854	5073502.399	30.5	9.4	0.66	3.63	---	<1
GW-OPLAW	8/10/2002	716444.262	5069256.037	12.2	3.4	0.50	7.09	585	3
GW-RWS-1	8/10/2002	710334.961	5063171.574	18.3	5.2	0.92	artesian	artesian	>20
GW-LWRD-1	8/10/2002	704957.417	5059082.397	18.3	5.5	0.60	3.67	360	5
GW-CORN-1	7/10/2002	718384.390	5055559.956	24.4	10.2	0.73	3.59	---	1
GW-MCKI-1	7/10/2002	714447.643	5055659.774	12.2	3.9	0.68	2.06	---	2-3

The methodology used to drill the monitor wells was as follows:

a) A 200 mm diameter hole was drilled through the overburden and terminated 0.3 m into the bedrock;

b) A 150 mm diameter steel casing with drive shoe was lowered down the open hole and seated in the bedrock;

c) The annulus between the well casing and the drilled hole was filled to the ground surface with bentonite grout;

d) The well was advanced below the casing using a 150mm diameter bit;

e) The well was developed by air lifting followed by inertial pumping with a Waterra Hydrolift II pumping system;

f) Locking covers were installed at the top of each well.

It is important to emphasize that all wells were installed in bedrock. For this reason, installation was limited to casing the surficial sediments – otherwise the hole was simply left open. Filter sand, screens and PVC wells were not installed.

Well development involves the removal of fine sediment particles from the rock formation by pumping water from each well. The purpose of the well development is to obtain a good hydraulic link between the well and the aquifer groundwater, and to remove as many fine sediments as possible. Typically, the drilling process will disturb the rock formation surrounding the hole. This change in the physical structure of the aquifer material will affect the permeability of the local formation, and may indeed change the chemistry also.

When using the Waterra pump for development, a 51 mm rigid PVC pipe with a 1.5 m screen was placed in all open holes to facilitate the water pumping. A dedicated high density polyethylene (HDPE) tubing of 13 mm equipped with a foot valve (D-32 from Waterra) was placed inside the 51 mm PVC tubing to allow the development and the groundwater sampling with an electrical pump (Waterra Hydrolift II). Without the rigid PVC pipe to support the (flexible) HDPE tubing, inertial pumping was almost impossible.

While the installation of a 51 mm PVC tubing and screen in all open wells was necessary to allow the Waterra pump to function properly, but it also prevented a true development in the wells, as it greatly reduced the surge energy from the pump from reaching the walls of the well. This in turn prevented the effective removal of all fine sedimentation from the walls of the well.

To avoid cross-contamination between drilling sites, the drilling bit, augers and soil sampling equipment (split spoon) were decontaminated using the following procedure:

1. Washing with high pressure water and brushing in a phosphate free detergent solution.

2. Washing with a solution containing 10% hydrochloric acid.

3. First rinse with distilled (purified) water.

4. Cleaning with acetone.

5. Final rinse with distilled water.

3.4 Sampling & analysis

All groundwater and surface water samples were analyzed for metals, major anions, and energetic materials. As well, parameters common to the general chemistry of the samples were analyzed: pH, alkalinity, nitrates, phosphates, total organic carbon, total suspended solids and turbidity were also analyzed. Analytical results can be found in

Appendix B on the CD ROM attached to this report. Physicochemical results may be found in Appendix C.

The energetic species were tested by RPC labs of Fredericton, NB, using EPA method 8330. Species analyzed included HMX, RDX, Tetryl, TNT and the major TNT breakdown products. Thirty-two metals were tested for in each sample. The quantification limits obtained for energetic materials in the present study was 1 ppb for aqueous samples Based on interferences peaks.

AMEC labs of Mississauga, Ontario performed the analysis for perchlorated in 22 representative samples using Dionex DX 120 ion chromatograph with an AS-14 column with guard column and Chameleon software. The perchlorate analysis methodology was proprietary to Dionex and had a detection limit of 0.5 mg/L. Samples chosen for analysis were obtained from areas closest to where perchlorate-bearing munitions have been used in the past, either as rocket propellant or as smoke/illumination rounds.

Groundwater samples were collected with the use of a Waterra Hydrolift II pump and a dedicated 13 mm HDPE tubing connected to a foot valve after the well development. Physicochemical parameters were also measured in the field with probes (YSI, Solinst Instruments, Burlington, ON) including temperature (T), pH, conductivity (Cond), salinity (sal), dissolved oxygen (DO) and oxidation-reduction potential (ORP). Appendix C of the CD ROM presents all the results for physicochemical parameters measured in the field.

Surface water and groundwater sampling was conducted under the guidance of INRS. A total of 58 wells were sampled including fourteen water supply wells for bivouac areas. Details of the bivouac wells are shown in Table 2. Six wells were sampled in duplicate for quality control (GW-HERS, GW-STRIP 2, GW-HANEY 2, GW-HIBERNIA, GW-ATR-1 and GW-BROWN-1). In addition, one sample of the water used for drilling was collected (DRILL WATER).

Table 2: Bivouac Wells Details

Point Name	Easting	Northing	Casing Elevation (m)	Ground Elevation (m)	Ellip Ht. (m)
DND4	698275.226	5078448.252	56.900	56.900	34.807
GW-BELL	708800.642	5049511.538	36.111	34.884	14.385
GW-CLONES	705792.702	5055243.236	129.478	128.741	107.641
GW-COOTES-1	710601.183	5049716.826	161.268	160.305	139.619
GW-HEARST-SPK	713675.291	5046786.535	******	135.352	113.814
GW-HIBERNIA	721500.502	5059249.861	156.525	156.029	135.194
GW-LYONS	711149.140	5045534.819	120.647	119.451	98.996
GW-MANOR	721261.717	5054097.796	161.656	160.861	140.351
GW-WORTHINGTON	710696.547	5052447.848	144.820	144.185	123.174
LAWFIELD	717354.239	5070961.294	50.139	50.139	28.576
OLD/DOT/CP	711538.869	5079013.947	53.047	53.047	31.285
PETERSVILLE	704713.286	5049662.926	174.233	174.233	152.323
SPRINGBOK	716300.215	5052908.776	162.740	162.740	141.311
STH/BDY/ROAD	704043.289	5063330.418	128.321	128.321	106.423

Water samples for energetic analysis were collected in a one litre amber glass bottles, stabilized with sodium bisulphate (1.5 g) and stored cold for transportation to RPC Labs of Fredericton. For total metal analyses, water samples were collected in standard 500 ml polyethylene bottles and acidified to a pH of 2.

The groundwater sampling procedures followed the protocol of the Quebec Ministry of the Environment (MENVQ, 1994), which requires purging of at least three pore volumes of groundwater from the filter pack, the PVC tubing and the screen prior to sampling. It also involves the field filtration of groundwater samples used for metal analysis prior to the acidification of the samples.

3.5 Hydrogeological testing of monitoring wells

Slug tests were done in all developed wells (except for ARG-1, ARG-2 and ARG-3) for an assessment of the hydraulic conductivity of the rock formation. Slug tests were conducted by removing water from the well with a bailer to drop the water level by approximately 60 cm below static level. The slug tests were performed at least twice in each well. In some wells, the availability of the range and the long time required to complete the test resulted in a single test being done. Data interpretation was done with the Bouwer & Rice method to evaluate the hydraulic conductivity. This data may be viewed in Appendix D of the CD attached to this report.

3.6 Water level measurements and water table map

Water level measurements were taken after well development. An electronic measuring tape (RST) with a precision of ± 0.5 cm was used to record the water depth in every well relative to the top of the PVC tubing. The water depth measurements were made during October 2002. The elevation was calculated in relation to the survey of the well's PVC tubing or casing. The elevation of the water table measured in the wells and the elevation of surface water from the topographic map were used to produce the water table elevation map. The hydraulic head contours were calculated using the kriging interpolation method with the Surfer software, 8.0 version.

3.7 Hydrodynamic modeling

A numerical hydrogeological model of the Gagetown military Base is a tool of great importance because it can take into account all the available information and thus can check the estimates of the hydrogeologic properties. Additionally, a numerical hydrogeological model provides insight into the behaviour of the regional hydrodynamics of the site. Most importantly for the end user, such a model can also be used as a management tool for the groundwater resources within the area and check for the favourable uptake zones for drinking water and also vulnerable zones thus determining the impact of future or already existing installations.

There are several trademark software products that could be used to portray the hydrogeological model of natural hydrodynamic systems such as the Gagetown military Base area. Possible models include: Modflow (McDonald and Harbaugh, 1988), Feflow (Dierch H-JG, 1998) and Hydrosphere (Therrien et al. 2003). In this study we have adopted the Hydrosphere model, because of its widespread use within several research teams at INRS, Laval University, University of Waterloo, etc. and its use in various recent natural hydrogeologic problems. The Hydrosphere model is a finite elements three-dimensional model currently designed to integrate all the data of the natural system, i.e. the weather, hydrologic, hydrographic and hydrogeologic data. The model contains a pre and post-processor (using the GMS package) to facilitate handling of the input/output files. The Hydrosphere model enables us to achieve the goal of this study, which consists in building a steady state regional hydrogeological model. The Hydrosphere model is well adapted to the Gagetown area problem especially because the following approximations are considered:

1- The surficial sedimentary deposits are ignored in the modeling because of their dispersion in the area and the deposits are considered thin (0 to 20 m) by comparison to those of the rock aquifer or the large extent of the field (over a 40 km X 40 km in area);
2- The recharge of the bedrock aquifer takes into account surficial sediments;
3- The Base of the aquifer in the bedrock is located at 500 m elevation below the sea level.

The goal of this work was to develop a regional, steady-state hydrogeological model for CFB Gagetown and its surroundings. The steps involved to achieve this were:

1) Identifying geological and hydrological features to delimit the area of study;

2) Compiling geological data, obtained both during the drill campaigns and from previous work;

3) Compiling hydrogeological data, obtained both during the drill campaigns and from previous work;

4) Analysis of meteorological data to establish aquifer recharge rates;

5) Selection of modeling software and establishing acceptable approximations;

6) Construction of the physical model starting from a digital elevation model (DEM);

7) Integration of field data into the model and running simulations.

3.8 Consultants and contractors

Field work was done under the supervision of Jean-Marc Ballard from INRS. All contracts were the responsibility of Defence Construction Canada. Dillon consulting, Fredericton office was employed to assist in the collection of samples and supervision of the drill team. Dillon was involved in the coordination of the various sampling teams, supervision of the drill team, purging and well development, sampling and measurement of wells. They also assisted during the well monitor survey, conducted by Traynor Surveys Ltd of Fredericton. Dayes Well Drilling of Brown's Flat NB handled borehole drilling and well installation.

Analytical work was performed by RPC labs, 921 College Hill Road, Fredericton NB, E3B 6Z9. RPC handled analyses for the general chemistry, explosives and metals analyses. AMEC Earth & Environmental Ltd, 160 Traders Blvd East, unit 4 Mississauga ON, L4Z 3K7 handled the perchlorate analyses.

3.9 GPS location survey

Traynor Surveys provided GPS locations (northing and easting) to the nearest centimetre, and elevations to the nearest millimetre relative to sea level of all monitoring wells using the steel casing as reference.

4. Results and discussion

4.1 Hydrogeological context

As was discussed in Section 2.3, the surficial geology of the Gagetown Base is fairly uniform and consists predominantly of glacial sediments, mainly till, directly overlying bed rock. Till thickness varies significantly within the study area, being generally thin and discontinuous in the southern part of the Base while moderately thick (1 to 6 m) and continuous in the northern part. The till matrix is typically very compact, reddish-brown and silt-rich over the gently rolling Pennsylvanian terrains in the northern part of the Base while it is generally greyish, less compact and sandier in hilly Silurian-Devonian terrains in the southern part. These ubiquitous basal tills are characterized by low permeability while the loose, sandy ablation tills which cover some areas in the northern part of the Base are much more permeable. Other types of surficial sediments (glaciofluvial, marine and alluvial) cover only small areas of the Base, mainly valley floors, particularly that of the Nerepis River valley. The total thickness of Quaternary sediments observed during drilling during the two Phases varies from 1 to 20 m with a mean value of 4.7 m. The origin of the Quaternary sediments is essentially glacial. The grain size of these glacial sediments is characterized by the presence of a fine matrix, which gives a low permeability to the soil.

Due to the irregular thickness, discontinuous nature and mostly low permeability of the surficial sediments, they do not constitute a significant aquifer. The surficial sediments act rather as an aquitard and when present in sufficient thickness under the piezometric surface they induce confined or semi-confined conditions on the underlying bedrock aquifer. The regional aquifer underlying the CFB Gagetown is formed by the fractured bedrock. The hydraulic properties of bedrock and sediments were determined by a pumping test, packer tests on two wells and slug tests on most observation wells. These properties are quite variable and seem related to the diverse lithologies underlying the Base. The average hydraulic conductivity is relatively low (10^{-5} to 10^{-6} m/s) but it can be locally high such as in sand and gravel accumulations as seen in Phase I (10^{-3} m/s) as well as in some conglomerate and sandstone horizons.

The hydraulic head surface map of the bedrock aquifer was generated Based on water levels measured in wells drilled in October 2002 (Map 5 joined to this report) and also from existing wells located on the Base. The average depth of the water table below ground surface is 4.2 m with a maximum depth at 18.3 m.. The map was drawn by interpolation with the Surfer program from more than 60 points measured in October 2002. The piezometric map compares favourably to that produced in the 2001 Phase I report, lending confidence to these results. Groundwater flow is radial and discharges ultimately into the Saint-John River. The flow pattern is influenced by the topography of the land surface and represents a good example of a gravity-driven groundwater flow system. The observed hydraulic gradients vary from 0.001 to 0.024 with most values lying between 0.002 and 0.007.

The aquifer underlying the Base is generally confined or semi-confined. The unconfined part was identified according to the surficial geology and drilling logs. Those areas include the southern part of the study area covering the Rockwell Wood North range and part of the Rockwell Impact. Unconfined conditions were also identified in Lawfield Impact, Greenfield Impact and in the north part of Wellington and Grenade ranges. Groundwater can be recharged directly by the infiltration of precipitation in those zones. In such unconfined areas the aquifer is thus more vulnerable to contamination from surface activity. The potential for contamination is also higher in areas were surface sediments are thin or very permeable and the water level is near the land surface.

Of the new wells GW-RWS-1, GW-MCKL and GW-DING-1 were artesian, joining four from Phase I which were artesian: GW-GAGE-4, GW-AUSTERE-1, GW-GREEN-5 and GW-HERS-3.

4.2 Groundwater environmental conditions

Raw data for the groundwater analyses may be found in Appendix A and B of the attached CD. Annex C at the back of this report shows the analytical data as compared to CCME guidelines for agricultural livestock use. CCME guidelines are meant for potable water sources, and no guidelines are available for groundwater. Given that we are sampling groundwater that is not meant for human or agricultural consumption, a choice must be made as to which guideline is most suitable and representative. The guideline we chose was for agricultural livestock use.

Groundwater and surface water sampling was done respectively within and outside the Base limit to determine the natural background quality of groundwater and the potential impact of training activities on groundwater.

The 58 wells sampled on the Base were analyzed for 39 different dissolved parameters (not including the dissolved energetics analyses). Of these 2262 analyses, only 39 exceeded the CCME guidelines for agricultural livestock use. Of the 39 parameters exceeding CCME guidelines, 17 were for pH levels falling outside the acceptable range. This parameter is sensitive to atmospheric exposure, as CO_2 dissolved in the groundwater will escape upon it being exposed to lower (atmospheric) pressure at ground surface, resulting in a rise in pH. Indeed, 12 of the 17 samples with pH outside of the acceptable range were slightly higher than the guideline.

Thirteen of the parameters exceeding CCME guidelines were for dissolved manganese. Five others were for elevated dissolved concentrations of iron. These results are similar to those found during Phase I. The regional background concentrations of these elements were found in the New Brunswick groundwater quality database. The regional background values show that the high iron and manganese concentrations found within CFB Gagetown are related to natural high concentrations in this area rather than to training activities. The concentrations are also in keeping with the surface water samples, which revealed similar levels of iron. Twelve of the 22 surface water samples showed levels of iron above CCME guidelines. However, the surface water shows fewer samples (2) above the CCME guidelines for manganese.

These three parameters together account for 35 of the 39 parameters which fell outside CCME guidelines. Elevated levels of chloride were found in the Lyons bivouac well. Although no CCME guideline exists for sodium, it was also found in elevated levels in this well, indicating that the source is common salt.

Arsenic was found in elevated concentrations in one well, GW-Rock-1. This well will have to be resampled to confirm this result. The source could be related either to a local arsenopyrite presence in the aquifer rock or to a local unidentified anthropic source. GW-Rock-1 showed elevated levels of arsenic during Phase I as well, and

GW-Arg-1, though not exceeding the CCME guidelines, showed an elevated arsenic concentration in both Phase I and Phase II.

The last two samples with parameters exceeding the CCME guidelines were for chromium, in the Lyons and Manor bivouac wells.

It must also be pointed out that although levels did not exceed CCME guidelines, several elevated parameters were noted in the bivouac wells. Several metal species were found to have higher metals concentrations in the bivouac wells than in nearby monitoring wells. This is particularly true of the Lyons and Manor bivouac wells. It is hypothesized that these metals concentrations are due to degrading pump mechanisms, or to metal items such as ammunition being dropped down the wells. It must be stressed that the guidelines used were for agricultural water use. The bivouac well water should not be used for human consumption.

Energetic materials were also analysed in the surface water and groundwater samples. Although 17 samples showed extremely low levels of energetic materials during the Phase I trials, no energetic materials at all were detected during the Phase II trials. This would appear to confirm the possibility that the Phase I results – many of which were suspiciously close to 1.6 ppb – were the result of laboratory contamination during processing. It is otherwise very difficult to explain how nothing at all was found in this sampling campaign. Energetic materials are non-volatile and fairly persistent. Although they may be mineralized, the process takes time and produces breakdown products which were also tested for.

Likewise, no perchlorates were detected in the groundwater. These chemicals are used in some illumination and smoke producing munitions, and they have been detected on American training areas. The limit of detection (0.5 mg/L) was somewhat higher than anticipated, so levels of perchlorates lower than this limit may in fact be present. It is recommended that further sampling be conducted and the samples be tested at a laboratory capable of lower detection limits in the order of 1 ppb.

Based on the results of our groundwater sampling during Phases I and II of CFB Gagetown in 2001-2002, there does not seem to be either high level or widespread regional contamination of groundwater related to training activities.

4.2.1.1 Statistical analysis of groundwater analyses

We will begin with pH, the parameter which falls outside the CCME guidelines the most frequently. pH was measured both in the laboratory and during the field campaign. The two sets of results show a poor correlation with R^2 value of only 0.18. The mean values however, are in agreement: 8.00 for the lab, and 7.95 for the field samples. Given the excellent correlation between duplicates as measured in the laboratory, and given that several of the contractors were somewhat unfamiliar with the YSI instrument used for field measurements, the lab samples will be taken to be the most reliable. The laboratory measurements show generally alkaline pH with 17 values higher than the recommended limits established by CCME. Values obtained in groundwater samples vary from 6.8 to 9.3 with a mean value of 8.0.

With respect to dissolved metals, it should be pointed out that sampling bias may have played a role in the higher metal concentrations detected. A newer methodology – low flow sampling – has proved superior to the inertial pumping method used during this campaign. Low flow sampling picks up less particulate matter than inertial pumping. As metals samples are preserved with acid, particulate matter in the samples is prone to dissolving. If the particulate matter contains metals, there is a good chance that inerial pumping will bias the sample. This possibility will have to be explored in further sampling campaigns.

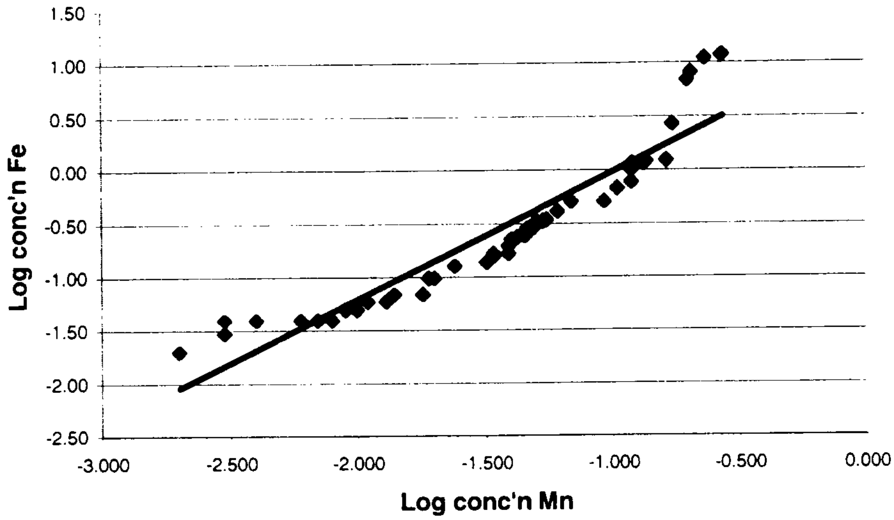

Figure 2: Log Fe vs. Log Mn in groudwater samples from Phase II sampling compaign

Arsenic was identified in GW-ROCK-1 in Phase II. This result is similar to the Phase I results which found high arsenic levels in the ROCK-1 and ARG-1 wells.

From the 2262 groundwater samples, 39 show at least one value higher than the upper limit established by the CCME, and 22 of these values were 1 standard deviation above the background levels. However, only 6 wells out of 58 had elemental concentrations 2 standard deviations above the background. Four of these were bivouac wells, and these will be discussed in further detail below. This is considerably fewer than in the Phase I analysis, where 16 wells out of 42 showed concentrations two standard deviations above background levels.

It is clear that the bivouac wells have much higher concentrations of some elements than the observation wells drilled for Phases II and I. 4 of the 11 bivouac wells had concentrations 2 standard deviations above the background concentrations, although only Lyons, Manor, Cootes and Clones showed levels of some parameters above CCME guidelines. As well, the bivouac wells showed high concentrations of elements that are not seen in any other wells. The Cootes, Lyons and Manor wells showed elevated values of zinc, chromium, cadmium when compared with background levels. These four elements were virtually undetected in any other wells. As mentioned above, this suggests that the higher metals concentrations found in the bivouac wells is caused by the corrosion of metal components from the well itself (pumps and metal casing), or metal debris dropped into the well. Cootes, Lyons and Manor were the only three wells in the entire study to show elevated levels of cadmium, chromium and lead respectively when compared with background levels.

For the purpose of establishing statistical background concentrations of the geochemistry of southern New Brunswick, a regional background comparison was performed in Phase I. Figure 4 presents limits of the area used for the regional comparison. Two comparisons were made: (1) with the proximate background around the military Base (270 samples) and (2) with a regional background which covers southern New Brunswick (896 samples).

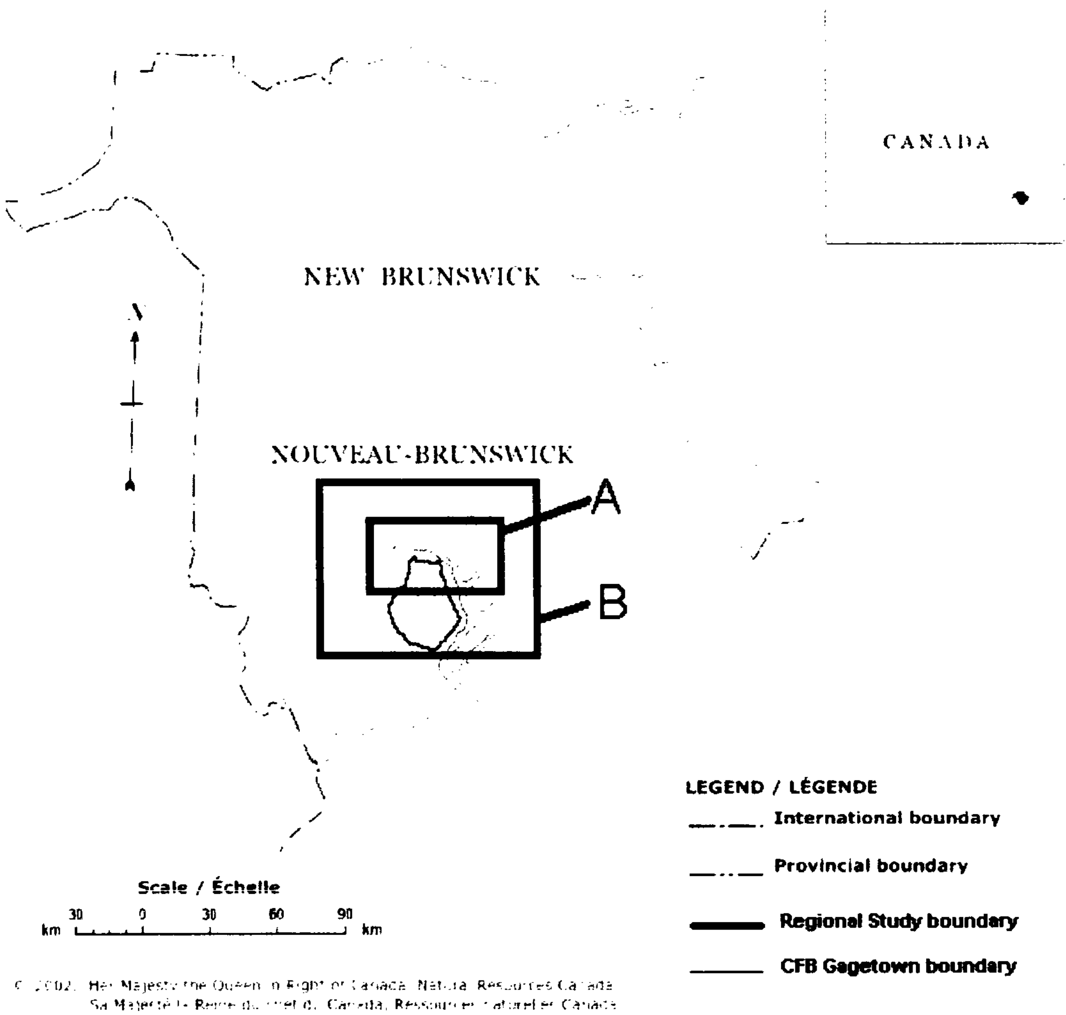

Figure 3. Limits Used for the Background Comparison: (A) Proximate background and (B) Regional Background

As was the case in Phase I, the majority of concentrations above the CCME guidelines were for iron and manganese. Aluminum was also found above CCME guidelines in Phase I, but the CCME guideline used (Freshwater aquatic life) was deemed inappropriate for Phase II. However, it is still important to establish if these concentrations are naturally occurring or not. The statistical distribution of data for these elements was compared at two different scales with histograms on logarithmic data. The results are presented in Table 9 and are from the New Brunswick groundwater data Base.

Table 3. Statistical limits for different backgrounds values of Al, Fe and Mn in groundwater for the Gagetown area (μg/L)

Elements	Regional Background (ppb)		Proximate Background (ppb)		CFB Gagetown (ppb)	
	Mean	Mean + 2 SD	Mean	Mean + 2 SD	Mean	Mean + 2 SD
Al	36.92	212.5	42.08	265.5	69.78	329.58
Fe	144.3	2770	139.4	2339	326.67	7262.4
Mn	38.87	1144	41.35	1014	128.76	469.42

The results for iron differ from those found for Phase I. Several very high values brought the mean concentration up to 326.67 ppb, which is roughly three times higher than the values for the regional and proximate background levels. The mean + 2 standard deviations of the Gagetown samples is similarly about 3 times higher than the same value found for regional and proximate samples, at 7262.4 ppb. Five of the samples are higher than 2770 ppb, which is the mean + 2 SD of regional samples. CCME guidelines recommend no more than 5 ppm for agricultural use. Two wells (GRE-1, 11.2 ppm and Haney-2, 12.1 ppm) showed exceptionally high levels of iron, both of which were over an order of magnitude higher than any other samples.

Manganese

The distribution of manganese in Gagetown Training area is fairly high but heterogeneous, with none above the 97.72% proximate limit of 1015 ppb. Manganese is the element most frequently found above the CCME guidelines in the CFB Gagetown groundwater, with 13 wells showing concentrations above the CCME agricultural limit of 0.2 ppm.

4.2.2 Energetics & perchlorates

Energetic materials were analysed in 87 groundwater samples according to EPA method 8330. As well, the water used for drilling was sampled. Depending on the species, detection limits ranged from 5 ppb (RDX) to 2.5 ppb (HMX, tetryl), to 1 ppb (all TNT metabolites). Fourteen species in all were tested for, with 10 of them being TNT metabolites. No explosives were found in any of the samples. The very low-level hits found during Phase I were not seen in this Phase II.

4.2.3 Surface water

During the sampling campaign, 22 surface water samples were collected around the military Base in the main water courses. Surface water samples collected presented pH values lower than the groundwater samples (mean value of 7.1 vs. 7.9 for groundwater) and the alkalinity is also lower (mean value of 18 mg/L for surface water versus 94 mg/L for groundwater). All pH are within the recommended values established by CCME (6.5 and 8.5) Complete results are presented in Appendices B & C of the attached CD ROM

Twelve of the 22 samples presented iron concentrations above the CCME limit of 0.3 mg/L for aquatic life. Only two samples showed manganese levels slightly above the CCME limit of 50 mg/L for community water. Three samples showed values above the recommended limits for aluminum. No energetic materials were detected in the surface waters.

4.2.4 Quality control of water samples

Quality control of water samples includes six field blanks and five duplicate samples. The water used for drilling was also sampled to verify the possibility of a cross-contamination. Laboratory blanks did not show any trace of metals or energetics and all the duplicates show similar results. Laboratory results seem to be reliable in regard with these observations.

4.3 Soil-Groundwater contamination patterns

The extensive soils sampling campaign performed in conjunction with the groundwater study, and reported in DRDC-Valcartier technical report TR 2003-016, indicated that over 20 metals were present on the training area above background levels. However, of nearly 100 soil samples taken only 12 showed levels of iron above background levels. No CCME guidelines exist for iron concentrations in soil. Similarly for manganese, only 7 samples were above background levels. This evidence supports the supposition that the iron and manganese found in the groundwater is not anthropic, and comes from natural sources. Given the very regular pattern of high levels of both elements in the groundwater, it is unlikely that these metals have leached from the surface. The wells showing the highest levels of metals, the bivouac wells, are located largely in the southern area of the Base, and no soil sampling was performed near them.

The small arms ranges complex in the northwestern area of the Base had numerous soil samples with high lead levels. The wells in this area (Haney-1, Haney-2, Arg-1, Arg-2, ATR-1, ATR-2, GRE-1 and GRE-2) do not show elevated levels of lead. Nor does the surface water sample SW-1 which was obtained nearby. Although the direction of flow from south to north indicates that SW-1 is water which has not passed through the small arms range area, it is the closest surface water site to yield results.

High levels of copper above CCME guidelines were found in several soil samples. In the groundwater, virtually no copper was found. The only wells containing copper were the bivouac wells, and these were two orders of magnitude below the acceptable limits.

4.4 Comparison of Phase I and Phase II results

The most significant similarity in the findings from Phases I and II of this study are the high level of iron and manganese found in groundwater throughout the Base. This trend is very clear in the results from both Phases. Another clear similarity is the general trend for high levels of alkalinity noted in both Phases. As a result of this, pH values were consistently high.

Arsenic, found above CCME guidelines (0.025 mg/L, drinking water or livestock watering)) in five wells during Phase I, exceeded the guidelines in only one well in Phase II. GW-Rock-1 had high levels of arsenic in both Phase I and Phase II. Vanadium, found in a single well during Phase I (Castle-1a), was not detected above the threshold limit of 0.1 ppm during Phase II.

Very low levels of energetic materials were detected in 17 wells during Phase I. No energetic materials were detected at all during Phase II in any wells. The most reasonable explanation is that the energetic materials detected in Phase I were a result of contamination somewhere in the chain of custody.

On the surface, the hydraulic properties of the rock aquifer are in agreement in both Phases, with conductivity K averaging around 10^{-6} m/s However, irregularities in the calculations performed during Phase I with the Bouwer and Rice analytical technique throw the results of this Phase in question. The Phase II conductivity measurements are considerably more reliable.

No Packers tests were performed during Phase II, so no comparisons can be made.

4.5 Physical testing of wells

Thirty six slug tests were performed in twenty different wells during Phase II. Twenty three of the tests in 12 wells gave data which was of good enough quality to fully analyze using the Bouwer & Rice method and the Cooper method. As well, eight further wells were analyzed with some assumptions made concerning the well construction. These eight wells were pre-existing, and data concerning the length of the well casing was unavailable. The results are presented in Appendix D.

During a slug test, a bailer is used to quickly remove a volume of water from each well. As water flows back into the well from the surrounding aquifer, a pressure transducer in a data logger (Level logger 3000 from Solinst) measures the gradual rise in the water level in the well. The rate of water flow into the well is related to the hydraulic conductivity of the surrounding rock formation. Subsequently, the data is read from the logger with a portable computer and converted in an Excel data spreadsheet for analysis. During the slug tests, the screened PVC pipe used for developing was removed from the well. Phase I slug tests showed an unexpected sinusoidal output with respect to the water depth which was traced back to the screened PVC pipe. The presence of the pipe in the well created two hydraulically linked chambers. The sudden lowering of water in one of the chambers caused a back-and-forth flow of water between the screened pipe and the well. To avoid this undesirable effect, the screened pipe was removed for the slug test performed in Phase II. Despite this precaution, several of the slug tests performed in Phase II still presented the sinusoidal increase and decrease in water level. This is observed when the inertia of the water column is not negligible ie. when the well has a long water column for short opening in high permeable geology material.

The hydraulic conductivity measured varies between $6.07x10^{-6}$ m/s to $1.51x10^{-4}$ m/s with a geometric mean of $4.9x10^{-5}$ m/s. This variation of several orders of magnitude is typical of widely varying stratigraphy in the Gagetown region.

Appendix D presents all the slug test results from each well. The hydraulic conductivity of the rock formations varies by two orders of magnitude. The grey shale formation is the most permeable whereas the least permeable is the grey siltstone. The Bouwer and Rice method of slug test interpretation was used in the calculation of results.

As was mentioned in section 4.4, irregularities in the calculations performed in the Phase I slug test analysis were noted. For this reason, comparisons were not made with the Phase I data. The observed hydraulic gradients vary from 0.001 to 0.024 with most values between 0.002 and 0.007. A discussion of estimates for hydraulic conductivity, porosity and storage coefficients is given in section 4.6.7. On the basis of this data, estimates for the linear groundwater velocity range between 7 m/day to 0.00001 mm/day, which is clearly an enormous variation. Numeric modelling is therefore critical to better understand the regional hydrodynamics, as no generalized predictions can be made on the basis of such widely differing calculations.

4.6 Hydrodynamic modeling

4.6.1 Features used to delimit model area

The study, being regional in context, required that we look outside the borders of the Base to find logical hydrological and geological features which would form the limits of the model. This allows the limits of the model to coincide with linear features where the water levels and/or flow rate are known. We chose the St John's River, the Oromocto River and its southern branch, the Number Ten Brook and the Douglas Valley Brook. As well, in the south-eastern area of the model, the drainage divides between the Nerepis River and St-John River watersheds was chosen as boundary. Map 1 attached to this report shows the study area boundaries.

4.6.2 Geological data used in modeling

The geology of the Base has been discussed in section 2.5, but some further details are necessary with regards to the modeling process. To begin with, for the purposes of the model, the surficial sedimentary deposits considered are: the till, the ablation till and sand and gravel. A simplified map of these deposits is shown in Map 2 attached to this report.

Another important point is that for the purposes of this model, CFB Gagetown was broken into three separate geological regions (Map 3, attached to this report). A more complete description of each unit is given in section 2.4, but recall that the northernmost region (unit 3) is composed of the Upper Carboniferous Pictou Formation. The formation which dominates the central area of the Base (unit 2) is composed of Lower Carboniferous and Devonian formations such as the Mabou Group, Mascarene Group and Piskahegan Group. The southernmost region (unit 1) contains the Kingsclear Group, Evandale Group, Welsford Group, and Mount Douglas Group dating from the Silurian and Ordovician.

4.6.3 Hydrogeological data used in modeling

During Phase I (2001) and Phase II (2002), several boreholes (Map 4, attached to this report) on the site enabled testing to determine the hydrogeologic properties of the aquifer - especially the hydraulic conductivity (Malcolm, 2003; Shaun, 2001). The tests included: Slug tests (45 boreholes were used), water injection tests between packers (4 tests in boreholes Pack-1 and Pack-2) and pumping tests (1 test in Hersey borehole). The interpretation of the data from these tests was made by the method of Bouwer and Rice (1976) and by the methods of Cooper for slug tests (Kruseman and Ridder, 1994) and finally by the method of Theis and Cooper-Jacob for the pumping test (Kruseman and Ridder, 1994; Todd, 1980) (Table 3). The result of this interpretation of these three methods is outlined in the Phase I technical report of Defence R&D Canada Valcartier (Thiboutot and al. 2003). The values for the hydraulic conductivities obtained are quite variable, thus reflecting the heterogeneous nature of the medium and the variation of lithological facies previously noted. Since the majority of the tests are slug tests, whose representation of the medium is especially local by comparison with the pumping test or injection test between packers, hydraulic conductivities which result from this are consequently specific to a given location. Ideally more data should be acquired (pumping test and slug test) because the hydraulic conductivity data is not available over the entire region of study. However, it seems that the data can be used in a regional context.

4.6.4 Meteorological data & recharge used in modeling

Groundwater recharge is a very important parameter for any hydrogeological study. Depending on the available data, estimates for aquifer recharge can be obtained by hydrological assessment methods if weather data are available. Another method studies the water table fluctuations in observation wells. Alternatively the method of river hydrograph separation can be used if hydrographic measurements exist and more particularly data on the gauging of the level of the rivers at discharge points of the watersheds.

The hydrometeorological data of the Gagetown area were obtained via the Internet by linking to the hydrometeorological dataBase of Environment Canada, and also via the data transfer of the hydrometeorological stations measurements of the Gagetown military Base. Seven Environment Canada weather stations are retained: Royal Road, Fredericton A, Fredericton cda, St-John A, Gagetown 2, Oromocto and Hoyt Blissville. An example of data of these stations is shown in Annex B. These last three stations are located within the study area. A measuring site for the flows in the Nerepis River near Fowler's corner, within the military Base, was considered to calculate the Base flow over the period of 1976 to 1993. The analysis of the water table fluctuations in two wells over the period of 2001 to 2003 was made using measurements of the New Maryland and Royal Road wells (Province of New Brunswick) stations. The estimated values of the recharge of the water table by these methods are indicated in table 4 and Appendix E and the description of the methods is described in the works of Rivard et al. (2004) and Healy and Cook (2002).

Table 4. Results of different methods used to calculate hydraulic conductivities

Name of the borehole	X	Y	Units	Slug Test				Pumping test			Packers test	
				Bouwer-Rice (m/s)			Cooper	Theis drawdown	Theis recovry	Cooper-Jacob		
				Test_1	Test_2	Test_3	m/s					
GW-BURP-2	702662,021	5081541,428	Unité3									
GW-BURP-4T	705676,224	5080830,639	Unité3	6,01E-04	5,79E-04		2,40E-06					
GW-PACK-2	711299,072	5079500,287	Unité3	5,70E-06	4,77E-06			8,10E-07	6,10E-07	8,10E-07	9,80E-07	1,60E-06
GW-PACK-1	711310,706	5079477,238	Unité3					2,40E-06		2,30E-06	1,50E-06	1,70E-06
GW-HERS-2	709012,498	5074430,712	Unité3	2,40E-06	2,88E-06			2,10E-07		2,60E-07		
GW-GREEN-5	706161,650	5078996,722	Unité3	1,24E-04	1,13E-04	1,22E-04	2,85E-04					
GW-GREEN-4	704361,338	5078792,983	Unité3				2,02E-06					
GW-ATR-2	701428,043	5077156,066	Unité3	7,00E-06	1,17E-05	8,65E-06	6,63E-06					
GW-GREEN-3	704493,558	5077050,073	Unité3				5,15E-07					
GW-ATR-1	701089,086	5076731,986	Unité3				1,35E-07					
GW-GRE-2	699840,578	5076575,125	Unité3				5,15E-07					
GW-GRE-1	700108,072	5076224,961	Unité3				2,20E-05					
GW-HERS-3	709972,914	5076192,222	Unité3	8,66E-05	7,44E-05							
GW-HERS-4	708921,937	5076072,794	Unité3				3,41E-05					
GW-DING-1	711462,701	5075514,032	Unité3	5,00E-06	4,53E-06							
GW-HANEY-3	697168,135	5074965,267	Unité3				1,51E-07					
GW-ARG-2	701205,963	5074449,258	Unité3	6,89E-06	1,46E-05	8,51E-06						
GW-GREEN-1	704595,073	5074180,063	Unité3	3,30E-05								
GW-HANEY-2	697304,552	5073904,754	Unité3				2,62E-07					
GW-HANEY-1	697335,091	5072788,998	Unité3				4,78E-06					
GW-HERS-1	710490,117	5072761,560	Unité3	6,74E-07								
GW-CDP-1	700195,220	5072219,563	Unité3	1,64E-05	1,74E-05		4,80E-05					
GW-LAW-2	714230,041	5070620,039	Unité3	4,97E-04	5,43E-04							
GW-ROCK-4	703268,499	5070590,472	Unité3				2,91E-06					
GW-LAW-3	713742,928	5069506,468	Unité3				2,01E-06					
GW-ROCK-3	704790,630	5069287,842	Unité3				1,14E-06					
GW-LAW-1	716004,817	5068727,900	Unité3	5,76E-04	6,48E-04	6,66E-04						
GW-LAW-4T	711661,468	5068565,241	Unité3	6,88E-04	5,40E-04							
GW-LAW-4R	711657,505	5068565,238	Unité3									
GW-DRUM-1	705100,635	5064687,804	Unité3									
GW-SBOUND-1	711911,778	5064589,633	Unité3				1,54E-06					
GW-BROWN-1	718075,840	5062743,224	Unité3	3,45E-06								
GW-LWRD-1	704957,417	5059082,397	Unité3	1,15E-05								
GW-HIBERNIA	721500,502	5059249,861	Unité2	2,87E-05								
GW-MCKI-1	714447,643	5055659,774	Unité2	2,30E-05								
GW-CORN-1	718384,390	5055559,956	Unité2	2,35E-05	5,83E-06							
GW-CLONES	705792,702	5055243,236	Unité2	5,42E-06								
GW-ORTHINGTON	710696,547	5052447,848	Unité2	6,79E-07								
GW-ENNI-1	700515,629	5051054,082	Unité2	7,25E-06	1,41E-05	1,05E-05						
GW-COOTES-1	710601,183	5049716,826	Unité1	3,30E-06	7,60E-06							
GW-BELL	708800,642	5049511,538	Unité1	2,12E-05	4,53E-05							
GW-MOUNT-1	722018,250	5049468,259	Unité1	1,50E-05								
GW-MOUNT-2	721964,623	5048500,034	Unité1	4,39E-05								
GW-ENNI-2	698979,572	5048085,921	Unité1	3,08E-06	1,45E-06							
GW-LYONS	711149,140	5045534,819	Unité1	5,87E-06								

Table 5. Calculated water table recharge of the gagetown aquifer

	X	Y	Years of observation	Methods	Yearly recharge (mm)
WEATHER STATIONS					
Royal Road	677145,75	5102596,80	1965-1990	Hydrologic mass balance	375
Fredericton A	692749,85	5082232,352	1951-1990		338
Fredericton cda	684822,231	5087550,718	1913-1990		311
St-John A	744285,813	5022848,000	1946-1990		505
Gagetown 2	721605,54	5072073,75	1897-1990		338
Oromocto	696806,97	5076799,33	1957-1990		319
Hoyt Blissville	689770,61	5052486,32	1981-2001		352
Stella Weather Station6			1989-2004		280
WELLS					
Royal Road	677145,75	5102596,80	2001-2003	Water table fluctuation in a well	382
New Maryland	679547,77	5083874,08	2001-2003		225
GAUGING STATION					
Nerepis River near Fowler's Corner	709326,947	5042235,865	1976-1993	River hydrograph separation	329

4.6.5 Digital elevation model (DEM)

The DEM was extracted from the of the Geomatics Canada dataBase following a regular grid of 100 m X 100 m to simulate the physical model. The above-mentioned was discretized according to triangular elements whose vertical extension forms a three-dimensional block with five layers. The Base of the model is selected at 500 m below the mean sea level in order to not influence the regional flow pattern. A graphical representation can be seen in Map 6, attached to this report. The model is thus composed of 109704 nodes and 180580 triangular elements. A refining mesh is imposed around a few wells and rivers.

4.6.6 Boundary conditions of the model

As we described earlier, the determination of the field dimensions was made in such a way that the limits of the model coincide with the natural limits where conditions of head and/or flux are known. The boundary conditions imposed are thus characterized by constant heads corresponding to the water levels along the St John River to the east and north, the Oromocto River to the west and south-west and finally the Nerepis River to the center of the south part of the field. No flow limit is imposed to the south along the watershed. Boundary limits are shown on Map 6 attached to this report.

4.6.7 Hydrogeologic properties

The hydrogeologic properties considered in this steady state regional modeling are hydraulic conductivities, effective porosities, as well as water levels. For the first parameter, values of hydraulic conductivities are variable from one geological unit to the other (although a few values are available from units 1 and 2, see Table 3). A distribution chart of hydraulic conductivities obtained by kriging interpolation of the entire territory (used in Surfer Package) and professional judgement of the modeller was used rather than inputting a mean value for each geological unit (Map 7 attached to this report shows the derived hydraulic conductivity map for CFB Gagetown). From this map one can distinguish that the area can be subdivided into 8 zones of different hydraulic conductivities. A number of zones will be better defined once additional hydraulic conductivity data are available. The values of the hydraulic conductivities and the effective porosities for each zone are shown in Table 5. In terms of the effective porosities, the values were obtained by using the water table recharge and fluctuations calculated by using the water levels and weather data from the Royal Road provincial well (Healy and Cook, 2002). Water level measurements took place during each of the two campaigns of 2001 and 2002. The measured piezometric map obtained is given in Map 5 attached to this report.

Table 6. Hydrogeologic parameters of the gagetown aquifer

Zone	Hydraulic conductivity (m/s)	Effective porosity %	Storage coefficient (%)
1	$3,16\ 10^{-6}$	1	0,001
2	$3,16\ 10^{-5}$	1	0,001
3	$5,44\ 10^{-6}$	10	0,01
4	$1,00\ 10^{-4}$	1	0,001
5	$3,16\ 10^{-4}$	1	0,001
6	$6,58\ 10^{-5}$	10	0,01
7	$1,00\ 10^{-4}$	10	0,01
8	$3,16\ 10^{-4}$	10	0,01

4.6.8 Water table recharge

As mentioned earlier, the groundwater recharge is an important parameter contributing to water table fluctuation and thus increases the groundwater reserves. This parameter is generally difficult to quantify and is not available in most cases for hydrogeological modeling, especially if the nature of the recharge zones is

Table 7. Values of bedrock aquifer recharge through surficial sediments and bedrock outcrops

Surficial Sediment	Recharge (mm/an)
Sand and gravel	500
Ablation till	300
Till	250
Rock	350

heterogeneous and/or no specific measurements are taken in the field. In our case, by using the data in Table 4, we tried to take this heterogeneity into account while trying to assign different values of recharge to each type of surficial sediment (Table 6).

4.6.9 Simulations & calibration of the model

A series of simulations were carried out with the aim to reproduce the hydrodynamics of the Gagetown aquifer using water level measurements from the years 2001 and 2002. During the calibration Phase variations of the values for hydraulic conductivity and recharge parameters occurred in order to adjust the calculated and observed hydraulic heads. Since the piezometric elevation in the Gagetown area varies between 0 and 160 m, an error of 5% on the piezometric variation (i.e. 8 m) was set as an acceptance criterion for the calibration convergence of the model. However, considering the large area of the simulated field and the amount of data missing within this field, the criterion was never reached. The best calibration adjustments, found in Figure 2, were obtained from data in Tables 7 and 8 with a mean error (ME) of 0,41m, a mean absolute error (MAE) of 13,18 m and a root means square error (RMS) of 17,85 m. The simulated hydrodynamic model of the aquifer system for the Gagetown military Base area is thus shown on Map 8 attached to this report and the difference between the observed and the simulated hydraulic head is shown on Map 9.

4.6.10 Future work

Given the difficulties encountered with reproducing the hydrodynamic reality of the aquifer underlying CFB Gagetown, it would be desirable to fill in the data gaps in order to increase the realism of the model. Of primary interest would be to drill several wells in areas that are poorly defined either geologically or hydrogeologically. Locations for these suggested wells are provided in Table 9.

Table 8. Hydrogeologic parameters used in map 8 following calibration

Zone	Hydraulic conductivity (m/s)
1	$2{,}5\ 10^{-6}$
2	$5{,}0\ 10^{-6}$
3	$8{,}0\ 10^{-6}$
4	$2{,}0\ 10^{-6}$
5	$1{,}0\ 10^{-6}$
6	$9{,}0\ 10^{-6}$
7	$4{,}0\ 10^{-5}$
8	$1{,}0\ 10^{-5}$

Table 9. Proposed additional wells in the CFB Gagetown (reference Map 10 and Map 11).

Proposed Well	X (Easting)	Y (Northing)	Description
1 2 3 4 5 6	723331,50 724745,69 718438,88 712505,94 704703,13 697624,13	5054901,50 5049292,50 5043724,50 5041643,00 5043709,00 5049903,00	Wells in unit 1 with at least one in each subwatershed. The location of these wells are chosen not far from the limit of the field in order to extend the knowledge of the hydrogeological properties (especially hydraulic conductivity) at these places and thus to increase the measuring point density on the territory.
7	705714,56	5047250,50	Located in unit 1 in the western part of the subwatershed SB-1.
8 9	720452,44 701038,94	5059491,50 5054522,00	Located in unit 2 towards the border of the field for the same reason as those of unit 1.
10 11 12 13	694763,59 710891,50 713952,00 706623,19	5054773,56 5057489,50 5050330,00 5054798,50	Located in subwatershed SB-1 of the unit 2 where missed data of the hydrogeological properties are notified.
14	719413,25	5067013,50	Need additional hydrogeological information near the limits of unit 3
15	712746,44	5073633,00	Located around shallow wells in unit 3
16 17	707755,31 707912,06	5072110,00 5066932,50	Need additional hydrogeological information in the middle of unit 3
18	712967,25	5062214,00	Need deep borehole at this location unit 3
19 20	703036,19 698451,19	5061518,50 5066043,50	Need additional hydrogeological information in the western part of unit 3
21 22 23	696333,88 693918,69 695158,06	5071430,00 5063100,50 5058691,00	Need to give new hydrogeological properties in the western part of unit 3
24	689901,35	5057968,33	Located in unit 3 and added for monitoring groundwater quality near the peopled zone at the western limit of the CFB Gagetown
25	691061,52	5053034,66	Located in unit 2 and added for monitoring groundwater quality near the peopled zone at the western limit of the CFB Gagetown
26	708155,39	5038251,22	Located in unit 1 and added for monitoring groundwater quality near the peopled zone at the south limit of the CFB Gagetown

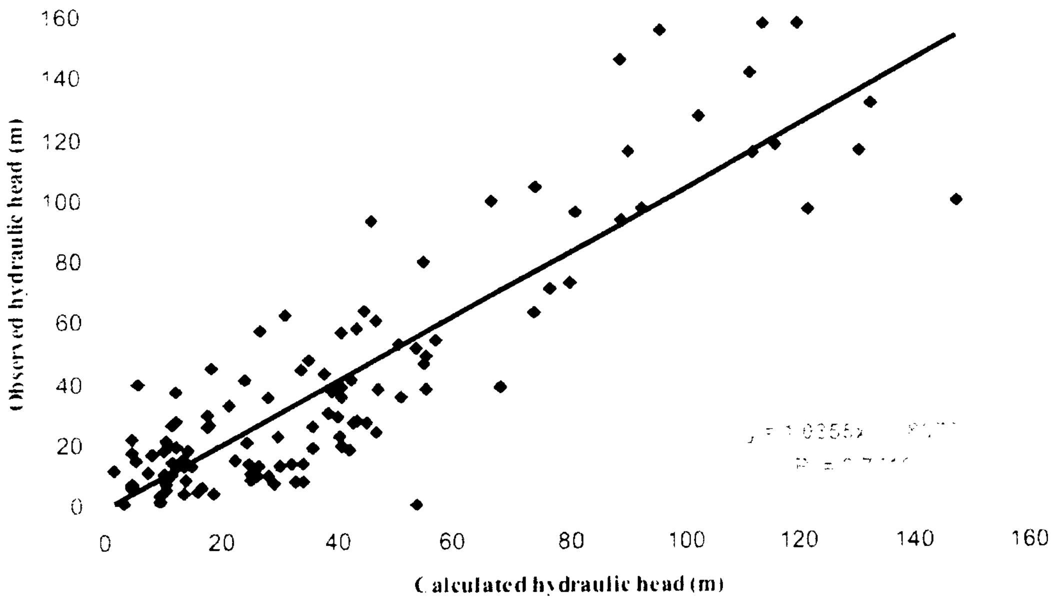

Figure 4. Comparison between calculated and observed hydraulic heads

Table 10. Water table recharge values through surficial sediment and bedrock after calibration of the model

Material deposit type	Recharge (mm/an)
Sand and gravel	300
Ablation till	200
Till	170
Rock	260

5. Conclusion

5.1 Geochemistry

The statistically elevated concentrations of metals found in the bivouac well presents the only immediate environmental concern identified during this study. The presence of chromium and chloride above CCME guidelines makes this is a potential health issue if the water from these wells is used for human consumption. The metal concentrations in the bivouac wells was higher than that found in nearby monitoring wells, which suggests that it is caused by the corrosion of metal components from the well itself (pumps and metal casing). Lyons and Manor were the only wells in the entire study to show statistically elevated levels of cadmium, chromium and lead respectively.

Further work will have to be done to confirm the metals concentrations found in the groundwater, but a sampling bias is quite likely the major reason for many elevated concentrations.

Low levels of energetic materials in the groundwater identified in the first Phase of this study in 2001 were not duplicated. No energetic materials were detected in any samples above the detection limit (1 ppb) of the analytical method. This was also the case for the perchlorate samples, although the detection limit for perchlorate (0.5 ppm) was rather high.

It must be emphasized that not finding any energetic or perchlorate residues in the groundwater samples does not mean that not contamination exists. Proving the absence of contamination requires substantially more effort than proving its presence. Contamination may in fact exist outside of the study area, where no wells are currently installed. Proving the absence of all contamination will require more wells be installed.

5.2 Modeling

At this stage in the modeling, a first version of a steady state numerical hydrogeological model of the Gagetown military Base aquifer was obtained. This model is important in the sense that it is now possible to reproduce the hydrodynamic behaviour of the natural system and also because the model can be used as a background for any future modeling studies of the groundwater resource management in this area. However, the quality of the results and the predictive ability of this model in its current state, is not ideal and should be used with caution because it is Based on a rather limited number of hydrogeologic information on the entire study area, this includes:

- Only one pumping test and two water injection tests between packers done in the geological unit 3
- A rather low number (15) of boreholes in geological units 1 and 2
- Shallow borehole generally not exceeding 20 meters depth;
- No time series data of water levels in wells for the entire study area;

- Lack of adequate hydrometeorological measurements, especially precipitations (rain and snow) and gauging in rivers;

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Annex A – Borehole logs

Dillon Consulting Ltd

Monitor Well: GW-BROWN-1

Project: DRDC- Explosive Residue Inv.
Project No: 02-0906-2000
Date: October 09, 2002

Location: CFB Gagetown, NB
Supervisor: JD Williams
Client: DCC Job No. GA18789

SUBSURFACE PROFILE				SAMPLE					MONITOR WELL		
Depth (m)	Symbol	Description	Elevation (m)	Method	Sample No.	N - Value	Recovery %	Field VOC (ppm)	Water Level	Well Data	Remarks
0–19 ft / 0–5.8 m		*GLACIAL TILL* *Reddish brown SILT, SAND and GRAVEL*	71								*150mm dia. steel casing 0.76 m stick-up*
			70								*50mm PVC casing with 3m 0.010 slot screen installed in 150 mm dia. monitor well*
			69	G G	*SA 1*						
			68								*50mm PVC Casing*
			66	G G	*SA 2*						
19–22 ft / 5.8 m+		*BEDROCK* *Purplish grey SANDSTONE*	65								*150 mm steel casing installed to 9.4 m BGS. Bentonite grout utilized to seal casing and overburden / bedrock from surface water*

Depth scale: 1–22 (ft); 1–6 (m). Elevation scale: 71, 70, 69, 68, 67, 66, 65.

Static Water Level: 21.09 m
Ground Surface Elev: 71.42 m
Sheet: 1 of 5

Groundwater Elev: 51.09 m
Top of Casing Elev: 72.18 m

LEGEND

* - Submitted to Lab
SWL - Water Level
TOC - Top of Casing

Split Spoon	Clay	Fill	PVC Casing
Hollow Stem Auger	Bedrock	Sand & Gravel	Core
Grab	Silty Clay Till	Sand	PVC Screen
	Gravel	Organics	J-Plug

Dillon Consulting Ltd

Monitor Well: GW-BROWN-1

Project: DRDC- Explosive Residue Inv. **Project No:** 02-0906-2000 **Date:** October 09, 2002

Location: CFB Gagetown, NB **Supervisor:** JD Williams **Client:** DCC Job No. GA18789

SUBSURFACE PROFILE				SAMPLE					MONITOR WELL		
Depth (m)	Symbol	Description	Elevation (m)	Method	Sample No.	N - Value	Recovery %	Field VOC (ppm)	Water Level	Well Data	Remarks
23 – 7		*BEDROCK* *Purplish grey SANDSTONE*									
24			64								
25											
26 – 8											
27											
28			63								
29											
30 – 9											
31			62								
32											
33 – 10											*50mm PVC casing*
34			61								
35											
36 – 11											
37											
38			60								
39 – 12				G G	SA 3						
40		*Colour change to grey*									
41			59								
42											
43 – 13											
44			58								

Static Water Level: 21.09 m Ground Surface Elev: 71.42 m Sheet: 2 of 5

Groundwater Elev: 51.09 m Top of Casing Elev: 72.18 m

LEGEND

* - Submitted to Lab SWL - Water Level TOC - Top of Casing	Clay	Fill	PVC Casing
Split Spoon	Bedrock	Sand & Gravel	Core
Hollow Stem Auger	Silty Clay Till	Sand	PVC Screen
Grab	Gravel	Organics	J-Plug

Dillon Consulting Ltd

Monitor Well: GW-BROWN-1

Project: DRDC- Explosive Residue Inv. **Project No:** 02-0906-2000 **Date:** October 09, 2002

Location: CFB Gagetown, NB **Supervisor:** JD Williams **Client:** DCC Job No. GA18789

Depth (ft)	Depth (m)	Description	Elevation (m)	Method	Sample No.	N - Value	Recovery %	Field VOC (ppm)	Water Level	Well Data	Remarks
45		*BEDROCK* *Purplish grey SANDSTONE*									
46	14										
47			57								
48–49	15										
50–51		*Reddish brown siltstone fragments noted in cuttings*	56	G G	SA 4						
52–53	16										
54–55			55								50mm PVC casing
56–57	17		54								
58–60	18	*Reddish brown SILTSONE/MUDSTONE*	53	G G	SA 5						
61–63	19										
64–66	20		52								

Static Water Level: 21.09 m

Groundwater Elev: 51.09 m

Ground Surface Elev: 71.42 m

Top of Casing Elev: 72.18 m

Sheet: 3 of 5

LEGEND

* - Submitted to Lab
SWL - Water Level
TOC - Top of Casing

Split Spoon | Hollow Stem Auger | Grab | Clay | Bedrock | Silty Clay Till | Gravel | Fill | Sand & Gravel | Sand | Organics | PVC Casing | Core | PVC Screen | J-Plug

Dillon Consulting Ltd

Monitor Well: GW-BROWN-1

Project: DRDC- Explosive Residue Inv. **Project No:** 02-0906-2000 **Date:** October 09, 2002

Location: CFB Gagetown, NB **Supervisor:** JD Williams **Client:** DCC Job No. GA18789

SUBSURFACE PROFILE				SAMPLE					MONITOR WELL		
Depth (m)	Symbol	Description	Elevation (m)	Method	Sample No.	N - Value	Recovery %	Field VOC (ppm)	Water Level	Well Data	Remarks
67–88 ft (21–26 m)		*Reddish brown SILTSONE/MUDSTONE*	51 – 45								
~22.6				G	SA 6						
~24											*50mm PVC Casing*
~25.8				G	SA 7						
25.9		*- colour change to dark grey at 25.9m*									

Static Water Level: 21.09 m Ground Surface Elev: 71.42 m Sheet: 4 of 5

Groundwater Elev: 51.09 m Top of Casing Elev: 72.18 m

LEGEND

* - Submitted to Lab
SWL - Water Level
TOC - Top of Casing

Split Spoon · Hollow Stem Auger · Grab · Clay · Bedrock · Silty Clay Till · Gravel · Fill · Sand & Gravel · Sand · Organics · PVC Casing · Core · PVC Screen · J-Plug

Dillon Consulting Ltd

Monitor Well: GW-BROWN-1

Project: DRDC- Explosive Residue Inv. **Project No:** 02-0906-2000 **Date:** October 09, 2002

Location: CFB Gagetown, NB **Supervisor:** JD Williams **Client:** DCC Job No. GA18789

Depth (ft)	Depth (m)	Symbol	Description	Elevation (m)	Method	Sample No.	N - Value	Recovery %	Field VOC (ppm)	Water Level	Well Data	Remarks
89	27											50mm PVC Casing
90			Grey SANDSTONE	44								
91												
92	28											
93				43								
94												
95	29											50mm PVC screen
96												
97			Dark grey SILTSTONE	42	G G	SA 8						
98	30											
99												
100				41								
101			End of monitor well at 30.5 m									
102	31											
103			Driller Estimated yield: <1 gpm	40								
104												
105	32											
106				39								
107												
108	33											
109												
110				38								

Static Water Level: 21.09 m Ground Surface Elev: 71.42 m Sheet: 5 of 5

Groundwater Elev: 51.09 m Top of Casing Elev: 72.18 m

LEGEND

* - Submitted to Lab
SWL - Water Level
TOC - Top of Casing

Split Spoon, Hollow Stem Auger, Grab, Clay, Bedrock, Silty Clay Till, Gravel, Fill, Sand & Gravel, Sand, Organics, PVC Casing, Core, PVC Screen, J-Plug

Dillon Consulting Ltd

Monitor Well: GW-CORN-1

Project: DRDC- Explosive Residue Inv. **Project No:** 02-0906-2000 **Date:** October 07, 2002

Location: CFB Gagetown, NB **Supervisor:** JD Williams **Client:** DCC Job No. GA18789

SUBSURFACE PROFILE				SAMPLE					MONITOR WELL		
Depth (m)	Symbol	Description	Elevation (m)	Method	Sample No.	N - Value	Recovery %	Field VOC (ppm)	Water Level	Well Data	Remarks
		GLACIAL TILL *Brown SILTY, SAND and GRAVEL, with trace COBBLES and BOULDERS throughout.*									*150mm dia. steel casing 0.73 m stick-up*
1			98								*50mm PVC casing with 3m 0.010 slot screen installed in 150 mm dia. monitor well*
2			97								
3			96								
4			95								*50mm PVC Casing*
5			94								
6			93								

Depth scale (ft): 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22

Static Water Level: 3.59 m

Groundwater Elev: 96.26 m

Ground Surface Elev: 99.12 m

Top of Casing Elev: 99.85 m

Sheet: 1 of 4

LEGEND

* - Submitted to Lab
SWL - Water Level
TOC - Top of Casing

Split Spoon	Clay	Fill	PVC Casing
Hollow Stem Auger	Bedrock	Sand & Gravel	Core
Grab	Silty Clay Till	Sand	PVC Screen
	Gravel	Organics	J-Plug

Dillon Consulting Ltd

Monitor Well: GW-CORN-1

Project: DRDC- Explosive Residue Inv.	**Project No:** 02-0906-2000	**Date:** October 07, 2002
Location: CFB Gagetown, NB	**Supervisor:** JD Williams	**Client:** DCC Job No. GA18789

SUBSURFACE PROFILE				SAMPLE					MONITOR WELL		
Depth (m)	Symbol	Description	Elevation (m)	Method	Sample No.	N - Value	Recovery %	Field VOC (ppm)	Water Level	Well Data	Remarks
23–30 ft / 7–9 m			92, 91, 90								
31 ft		BEDROCK CONGLOMERATE									150 mm steel casing installed to 10.2 m BGS. Bentonite grout utilized to seal casing and overburden / bedrock from surface water
32–37 ft / 10–11 m			89, 88								
38 ft				G, G	SA 1						50mm PVC casing
39–44 ft / 12–13 m			87, 86								

Static Water Level: 3.59 m	Ground Surface Elev: 99.12 m	Sheet: 2 of 4
Groundwater Elev: 96.26 m	Top of Casing Elev: 99.85 m	

LEGEND

* - Submitted to Lab
SWL - Water Level
TOC - Top of Casing

Split Spoon	Bedrock	Sand & Gravel	Core
Hollow Stem Auger	Silty Clay Till	Sand	PVC Screen
Grab	Gravel	Organics	J-Plug
	Clay	Fill	PVC Casing

Dillon Consulting Ltd

Monitor Well: GW-CORN-1

Project: DRDC- Explosive Residue Inv. **Project No:** 02-0906-2000 **Date:** October 07, 2002

Location: CFB Gagetown, NB **Supervisor:** JD Williams **Client:** DCC Job No. GA18789

SUBSURFACE PROFILE				SAMPLE					MONITOR WELL		
Depth (m)	Symbol	Description	Elevation (m)	Method	Sample No.	N - Value	Recovery %	Field VOC (ppm)	Water Level	Well Data	Remarks
45–66 ft / 14–20 m		*BEDROCK CONGLOMERATE*	85–79								*50mm PVC casing*
48–49.5 ft			~84.5–84	G G	SA 2						
57–58.5 ft			~81.6–81	G G	SA 3						

Static Water Level: 3.59 m Ground Surface Elev: 99.12 m Sheet: 3 of 4

Groundwater Elev: 96.26 m Top of Casing Elev: 99.85 m

LEGEND

* - Submitted to Lab
SWL - Water Level
TOC - Top of Casing

Split Spoon | Hollow Stem Auger | Grab | Clay | Bedrock | Silty Clay Till | Gravel | Fill | Sand & Gravel | Sand | Organics | PVC Casing | Core | PVC Screen | J-Plug

Dillon Consulting Ltd

Monitor Well: GW-CORN-1

Project: DRDC- Explosive Residue Inv. | **Project No:** 02-0906-2000 | **Date:** October 07, 2002

Location: CFB Gagetown, NB | **Supervisor:** JD Williams | **Client:** DCC Job No. GA18789

SUBSURFACE PROFILE				SAMPLE					MONITOR WELL		
Depth (m)	Symbol	Description	Elevation (m)	Method	Sample No.	N - Value	Recovery %	Field VOC (ppm)	Water Level	Well Data	Remarks
67–80 ft (20.4–24.4 m)	Bedrock	CONGLOMERATE cont'd	78–75								
75 ft (23 m)			76	G	SA 4						50mm PVC screen
80–88 ft (24.4–26.8 m)		End of monitor well at 24.4 m Drillers Estimated yield : 1 gpm	75–73								

Depth scale (ft): 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88; (m): 21, 22, 23, 24, 25, 26

Elevation scale (m): 78, 77, 76, 75, 74, 73

Static Water Level: 3.59 m

Groundwater Elev: 96.26 m

Ground Surface Elev: 99.12 m

Top of Casing Elev: 99.85 m

Sheet: 4 of 4

LEGEND

* - Submitted to Lab
SWL - Water Level
TOC - Top of Casing

Split Spoon	Clay	Fill	PVC Casing
Hollow Stem Auger	Bedrock	Sand & Gravel	Core
Grab	Silty Clay Till	Sand	PVC Screen
	Gravel	Organics	J-Plug

Dillon Consulting Ltd

Monitor Well: GW-DING-1

Project: DRDC- Explosive Residue Inv. **Project No:** 02-0906-2000 **Date:** October 02, 2002

Location: CFB Gagetown, NB **Supervisor:** JD Williams **Client:** DCC Job No. GA18789

SUBSURFACE PROFILE		SAMPLE		MONITOR WELL
Depth (ft / m)	Description	Method	Sample No.	Remarks
0–9.5 ft (0–2.9 m)	*GLACIAL TILL* *Dark brown SILT, SAND and GRAVEL*			*150mm dia. steel casing 0.61 m stick-up*
5–7 ft		G, G	SA 1	*50mm PVC casing with 3m 0.010 slot screen installed in 150 mm dia. monitor well*
9.5–13 ft (2.9–4 m)	*BEDROCK* *Reddish brown SILTSTONE*			*150 mm steel casing installed to 2.9 m BGS. Bentonite grout utilized to seal casing and overburden / bedrock from surface water*
13–22 ft (4 m–)	*Reddish brown SANDSTONE*			
13–15 ft		G, G	SA 2	

Depth scale (ft): 1–22; (m): 1–6. Elevation (m): 38, 37, 36, 35, 34, 33, 32.

Other columns: Symbol, Elevation (m), N - Value, Recovery %, Field VOC (ppm), Water Level, Well Data.

Static Water Level: 0.00 m Ground Surface Elev: 38.65 m Sheet: 1 of 3

Groundwater Elev: 39.26 m Top of Casing Elev: 39.26 m

LEGEND

* - Submitted to Lab
SWL - Water Level
TOC - Top of Casing

Split Spoon, Hollow Stem Auger, Grab, Clay, Bedrock, Silty Clay Till, Gravel, Fill, Sand & Gravel, Sand, Organics, PVC Casing, Core, PVC Screen, J-Plug

Dillon Consulting Ltd

Monitor Well: GW-DING-1

Project: DRDC- Explosive Residue Inv.
Project No: 02-0906-2000
Date: October 02, 2002
Location: CFB Gagetown, NB
Supervisor: JD Williams
Client: DCC Job No. GA18789

Depth (ft)	Depth (m)	Description	Elevation (m)	Method	Sample No.	N - Value	Recovery %	Field VOC (ppm)	Water Level	Well Data	Remarks
23	7	*Reddish brown SANDSTONE*									
25			31								
26	8										
28		*Reddish brown SILTSTONE*	30	G	SA 3						
29	9			G							
32			29								*50mm PVC casing*
33	10										
35			28								
36	11										
38			27								
39	12										
42	13		26								
44											

Static Water Level: 0.00 m
Ground Surface Elev: 38.65 m
Sheet: 2 of 3
Groundwater Elev: 39.26 m
Top of Casing Elev: 39.26 m

LEGEND

* - Submitted to Lab
SWL - Water Level
TOC - Top of Casing

Split Spoon · Hollow Stem Auger · Grab · Clay · Bedrock · Silty Clay Till · Gravel · Fill · Sand & Gravel · Sand · Organics · PVC Casing · Core · PVC Screen · J-Plug

Dillon Consulting Ltd

Monitor Well: GW-DING-1

Project: DRDC- Explosive Residue Inv.
Project No: 02-0906-2000
Date: October 02, 2002
Location: CFB Gagetown, NB
Supervisor: JD Williams
Client: DCC Job No. GA18789

Depth (ft)	Depth (m)	Symbol	Description	Elevation (m)	Method	Sample No.	N - Value	Recovery %	Field VOC (ppm)	Water Level	Well Data	Remarks
45–58	14–17	Bedrock	*Reddish brown SILTSTONE cont'd*	25–21	G, G	SA 4					Casing / Screen	*50mm PVC casing*; *50mm PVC screen*
58–60	18	Bedrock	*CONGLOMERATE*	21	G, G	SA 5					Screen	
61–66	19–20		*End of monitor well at 18.3 m* *Driller Estimated yield: 2-3 gpm*	20–19								

Static Water Level: 0.00 m
Groundwater Elev: 39.26 m
Ground Surface Elev: 38.65 m
Top of Casing Elev: 39.26 m
Sheet: 3 of 3

LEGEND

* - Submitted to Lab
SWL - Water Level
TOC - Top of Casing

Split Spoon	Clay	Fill	PVC Casing
Hollow Stem Auger	Bedrock	Sand & Gravel	Core
Grab	Silty Clay Till	Sand	PVC Screen
	Gravel	Organics	J-Plug

Dillon Consulting Ltd

Monitor Well: GW-ENNI-1

Project: DRDC- Explosive Residue Inv.	**Project No:** 02-0906-2000	**Date:** October 04, 2002
Location: CFB Gagetown, NB	**Supervisor:** JD Williams	**Client:** DCC Job No. GA18789

SUBSURFACE PROFILE				SAMPLE					MONITOR WELL		
Depth (m)	Symbol	Description	Elevation (m)	Method	Sample No.	N - Value	Recovery %	Field VOC (ppm)	Water Level	Well Data	Remarks
0–0.6		*Weathered BEDROCK* Brown SANDSTONE, fine grained, becoming more competent at 0.6m BGS									*150mm dia. steel casing 0.42 m stick-up*
0.6–		*BEDROCK* BROWN SANDSTONE SHALE	120								*50mm PVC casing with 3m 0.010 slot screen installed in 150 mm dia. monitor well*
		Monitor well located at a former borrow source site	119								*150 mm steel casing installed to 1.5 m BGS. Bentonite grout utilized to seal casing and overburden / bedrock from surface water*
			118	G G	SA 1						
			117								*50mm PVC Casing*
			116								
			115	G G	SA 2						
			114								

Depth scale: 1–22 (ft); 1–6 (m)

Static Water Level: 6.75 m	Ground Surface Elev: 120.61 m	Sheet: 1 of 3
Groundwater Elev: 114.28 m	Top of Casing Elev: 121.03 m	

LEGEND

* - Submitted to Lab
SWL - Water Level
TOC - Top of Casing

Split Spoon, Hollow Stem Auger, Grab, Clay, Bedrock, Silty Clay Till, Gravel, Fill, Sand & Gravel, Sand, Organics, PVC Casing, Core, PVC Screen, J-Plug

Dillon Consulting Ltd

Monitor Well: GW-ENNI-1

Project: DRDC- Explosive Residue Inv.
Project No: 02-0906-2000
Date: October 04, 2002
Location: CFB Gagetown, NB
Supervisor: JD Williams
Client: DCC Job No. GA18789

SUBSURFACE PROFILE				SAMPLE					MONITOR WELL		
Depth (m)	Symbol	Description	Elevation (m)	Method	Sample No.	N - Value	Recovery %	Field VOC (ppm)	Water Level	Well Data	Remarks
23 ft / 7 m		*BEDROCK BROWN SANDSTONE SHALE*									
25 ft			113	G	SA 3						
26 ft / 8 m		*GREYWACKE*		G, G	SA 4						
28 ft			112								
30 ft / 9 m											*50mm PVC casing*
31 ft			111								
33 ft / 10 m											
35 ft			110								
36 ft / 11 m											
38 ft			109								
39 ft / 12 m		*Returns reddish brown in color at 12 m BGS and well yielding <= 1 gpm*									
40 ft				G	SA 5						
41 ft			108								
42 ft											*50mm PVC screen*
43 ft / 13 m											
44 ft											

Static Water Level: 6.75 m
Ground Surface Elev: 120.61 m
Sheet: 2 of 3
Groundwater Elev: 114.28 m
Top of Casing Elev: 121.03 m

LEGEND

* - Submitted to Lab
SWL - Water Level
TOC - Top of Casing

Split Spoon	Clay	Fill	PVC Casing
Hollow Stem Auger	Bedrock	Sand & Gravel	Core
Grab	Silty Clay Till	Sand	PVC Screen
	Gravel	Organics	J-Plug

Dillon Consulting Ltd

Monitor Well: GW-ENNI-1

Project: DRDC- Explosive Residue Inv. **Project No:** 02-0906-2000 **Date:** October 04, 2002

Location: CFB Gagetown, NB **Supervisor:** JD Williams **Client:** DCC Job No. GA18789

SUBSURFACE PROFILE				SAMPLE					MONITOR WELL		
Depth (m)	Symbol	Description	Elevation (m)	Method	Sample No.	N - Value	Recovery %	Field VOC (ppm)	Water Level	Well Data	Remarks
45–50 ft / 14–15 m	Bedrock		107–106	G, G	SA 6					PVC Screen	50mm PVC Screen
				G, G	SA 7						
50–66 ft / 15–20 m		End of monitor well at 18.3 m Driller Estimated yield: 2 gpm	105–101								

Static Water Level: 6.75 m Ground Surface Elev: 120.61 m Sheet: 3 of 3

Groundwater Elev: 114.28 m Top of Casing Elev: 121.03 m

LEGEND

* - Submitted to Lab
SWL - Water Level
TOC - Top of Casing

Split Spoon, Hollow Stem Auger, Grab, Clay, Bedrock, Silty Clay Till, Gravel, Fill, Sand & Gravel, Sand, Organics, PVC Casing, Core, PVC Screen, J-Plug

Dillon Consulting Ltd

Monitor Well: GW-ENNI-2

Project: DRDC- Explosive Residue Inv. **Project No:** 02-0906-2000 **Date:** October 04, 2002

Location: CFB Gagetown, NB **Supervisor:** JD Williams **Client:** DCC Job No. GA18789

Depth (ft)	Depth (m)	Description	Elevation (m)	Method	Sample No.	N - Value	Recovery %	Field VOC (ppm)	Water Level	Well Data	Remarks
0–22	0–6.7	*GLACIAL TILL* *Brown SILT, SAND and GRAVEL with trace COBBLES*									*150mm dia. steel casing 0.72 m stick-up*
											50mm PVC casing with 3m 0.010 slot screen installed in 150 mm dia. monitor well
3–5	1		96	G G	*SA 1*						
6–7	2		95								
10	3		94								
13	4		93								*50mm PVC Casing*
16–17	5		92								
20	6		91								
21–22				G							

Static Water Level: 0.27 m

Groundwater Elev: 97.37 m

Ground Surface Elev: 96.92 m

Top of Casing Elev: 97.64 m

Sheet: 1 of 4

LEGEND

* - Submitted to Lab
SWL - Water Level
TOC - Top of Casing

Split Spoon	Clay	Fill	PVC Casing
Hollow Stem Auger	Bedrock	Sand & Gravel	Core
Grab	Silty Clay Till	Sand	PVC Screen
	Gravel	Organics	J-Plug

Dillon Consulting Ltd

Monitor Well: GW-ENNI-2

Project: DRDC- Explosive Residue Inv. **Project No:** 02-0906-2000 **Date:** October 04, 2002

Location: CFB Gagetown, NB **Supervisor:** JD Williams **Client:** DCC Job No. GA18789

Depth (ft)	Depth (m)	Symbol	Description	Elevation (m)	Method	Sample No.	N - Value	Recovery %	Field VOC (ppm)	Water Level	Well Data	Remarks
23	7			90	G	SA 2						
24												
25												
26	8		*BEDROCK GREYWACKE*	89								
27												
28												
29												
30	9			88								
31					G	SA 3						
32												
33	10			87								*150 mm steel casing installed to 10.4 m BGS. Bentonite grout utilized to seal casing and overburden / bedrock from surface water*
34					G	SA 4						
35												
36	11			86								
37												
38												
39	12		*12 m BGS and well yielding <= 1 gpm*	85								*50mm PVC casing*
40												
41												
42	13			84								
43												
44												

Static Water Level: 0.27 m Ground Surface Elev: 96.92 m Sheet: 2 of 4

Groundwater Elev: 97.37 m Top of Casing Elev: 97.64 m

LEGEND

* - Submitted to Lab
SWL - Water Level
TOC - Top of Casing

Split Spoon	Clay	Fill	PVC Casing
Hollow Stem Auger	Bedrock	Sand & Gravel	Core
Grab	Silty Clay Till	Sand	PVC Screen
	Gravel	Organics	J-Plug

Dillon Consulting Ltd

Monitor Well: GW-ENNI-2

Project: DRDC- Explosive Residue Inv. **Project No:** 02-0906-2000 **Date:** October 04, 2002

Location: CFB Gagetown, NB **Supervisor:** JD Williams **Client:** DCC Job No. GA18789

Depth (ft)	Depth (m)	Symbol	Description	Elevation (m)	Method	Sample No.	N - Value	Recovery %	Field VOC (ppm)	Water Level	Well Data	Remarks
45			*BEDROCK GREYWACKE*									
46	14			83								
47–48					G	SA 5						
49	15			82								
50–51			- *Driller noted bedrock is softer* - *cuttings intermittent brown and grey*		G G	SA 6						
52	16			81								
56	17			80								*50mm PVC Screen*
58–59	18			79	G G	SA 7						
62	19		- *Driller noted bedrock becoming harder*	78								
65–66	20			77								

Static Water Level: 0.27 m | Ground Surface Elev: 96.92 m | Sheet: 3 of 4

Groundwater Elev: 97.37 m | Top of Casing Elev: 97.64 m

LEGEND

* - Submitted to Lab
SWL - Water Level
TOC - Top of Casing

Split Spoon, Hollow Stem Auger, Grab, Clay, Bedrock, Silty Clay Till, Gravel, Fill, Sand & Gravel, Sand, Organics, PVC Casing, Core, PVC Screen, J-Plug

Dillon Consulting Ltd

Monitor Well: GW-ENNI-2

Project: DRDC- Explosive Residue Inv. | **Project No:** 02-0906-2000 | **Date:** October 04, 2002

Location: CFB Gagetown, NB | **Supervisor:** JD Williams | **Client:** DCC Job No. GA18789

SUBSURFACE PROFILE				SAMPLE					MONITOR WELL		
Depth (m)	Symbol	Description	Elevation (m)	Method	Sample No.	N - Value	Recovery %	Field VOC (ppm)	Water Level	Well Data	Remarks
67–80 ft (21–24.4 m)	Bedrock	*Bedrock GREYWACKE cont'd*	76–72.5								*50mm PVC Screen*
78–80 ft			73	G	*SA 8*						
80–88 ft (24.4–26 m)		*End of monitor well at 24.4 m* *Driller Estimated yield: 2 gpm*	72–70								

Static Water Level: 0.27 m | Ground Surface Elev: 96.92 m | Sheet: 4 of 4

Groundwater Elev: 97.37 m | Top of Casing Elev: 97.64 m

LEGEND

* - Submitted to Lab
SWL - Water Level
TOC - Top of Casing

Split Spoon	Clay	Fill	PVC Casing
Hollow Stem Auger	Bedrock	Sand & Gravel	Core
Grab	Silty Clay Till	Sand	PVC Screen
	Gravel	Organics	J-Plug

Dillon Consulting Ltd

Monitor Well: GW-GAGE-1

Project: DRDC- Explosive Residue Inv. | **Project No:** 02-0906-2000 | **Date:** October 09, 2002

Location: CFB Gagetown, NB | **Supervisor:** JD Williams | **Client:** DCC Job No. GA18789

SUBSURFACE PROFILE				SAMPLE					MONITOR WELL		
Depth (m)	Symbol	Description	Elevation (m)	Method	Sample No.	N - Value	Recovery %	Field VOC (ppm)	Water Level	Well Data	Remarks
		GLACIAL TILL *Brown SILTY, SAND and GRAVEL overlying weathered bedrock*	65								*150mm dia. steel casing 0.66 m stick-up*
1		*Monitor well located at Airstrip 3*		G	*SA 1*						*50mm PVC casing with 3m 0.010 slot screen installed in 150 mm dia. monitor well*
		BEDROCK *CONGLOMERATE*	64								
2			63	G G G	*SA 2*						*150 mm steel casing installed to 9.4 m BGS. Bentonite grout utilized to seal casing and overburden / bedrock from surface water*
3			62								
4			61								*50mm PVC Casing*
5			60								
6			59	G G	*SA 3*						

Static Water Level: 3.63 m | Ground Surface Elev: 65.21 m | Sheet: 1 of 5

Groundwater Elev: 62.24 m | Top of Casing Elev: 65.87 m

LEGEND

* - Submitted to Lab
SWL - Water Level
TOC - Top of Casing

Split Spoon	Clay	Fill	PVC Casing
Hollow Stem Auger	Bedrock	Sand & Gravel	Core
Grab	Silty Clay Till	Sand	PVC Screen
	Gravel	Organics	J-Plug

Dillon Consulting Ltd

Monitor Well: GW-GAGE-1

Project: DRDC- Explosive Residue Inv. **Project No:** 02-0906-2000 **Date:** October 09, 2002

Location: CFB Gagetown, NB **Supervisor:** JD Williams **Client:** DCC Job No. GA18789

Depth (ft)	Depth (m)	Description	Elevation (m)	Method	Sample No.	N - Value	Recovery %	Field VOC (ppm)	Water Level	Well Data	Remarks
23–29	7–9	Reddish brown SILTSTONE	58, 57								
30–32	9	- Cuttings mixture of reddish brown and grey	56	G, G	SA 4						
33–37	10–11		55, 54								50mm PVC casing
38–40	12		53	G, G	SA 5						
41–44	13	Grey SANDSTONE	52								

Static Water Level: 3.63 m Ground Surface Elev: 65.21 m Sheet: 2 of 5

Groundwater Elev: 62.24 m Top of Casing Elev: 65.87 m

LEGEND

* - Submitted to Lab
SWL - Water Level
TOC - Top of Casing

Split Spoon, Hollow Stem Auger, Grab, Clay, Bedrock, Silty Clay Till, Gravel, Fill, Sand & Gravel, Sand, Organics, PVC Casing, Core, PVC Screen, J-Plug

Dillon Consulting Ltd

Monitor Well: GW-GAGE-1

Project: DRDC- Explosive Residue Inv.	**Project No:** 02-0906-2000	**Date:** October 09, 2002
Location: CFB Gagetown, NB	**Supervisor:** JD Williams	**Client:** DCC Job No. GA18789

SUBSURFACE PROFILE				SAMPLE					MONITOR WELL		
Depth (m)	Symbol	Description	Elevation (m)	Method	Sample No.	N - Value	Recovery %	Field VOC (ppm)	Water Level	Well Data	Remarks
45 ft – 14 m		*Grey SANDSTONE*									
48–50 ft / 15 m			50	G / G	SA 6						
54 ft			49								*50mm PVC casing*
60 ft / 18 m		*Reddish brown siltstone fragments*	47								
64 ft		*Brown SILTSTONE*	46								
66 ft / 20 m			45								

Depth scale (ft): 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66; (m): 14, 15, 16, 17, 18, 19, 20

Elevation scale (m): 51, 50, 49, 48, 47, 46, 45

Static Water Level: 3.63 m	Ground Surface Elev: 65.21 m	Sheet: 3 of 5
Groundwater Elev: 62.24 m	Top of Casing Elev: 65.87 m	

LEGEND

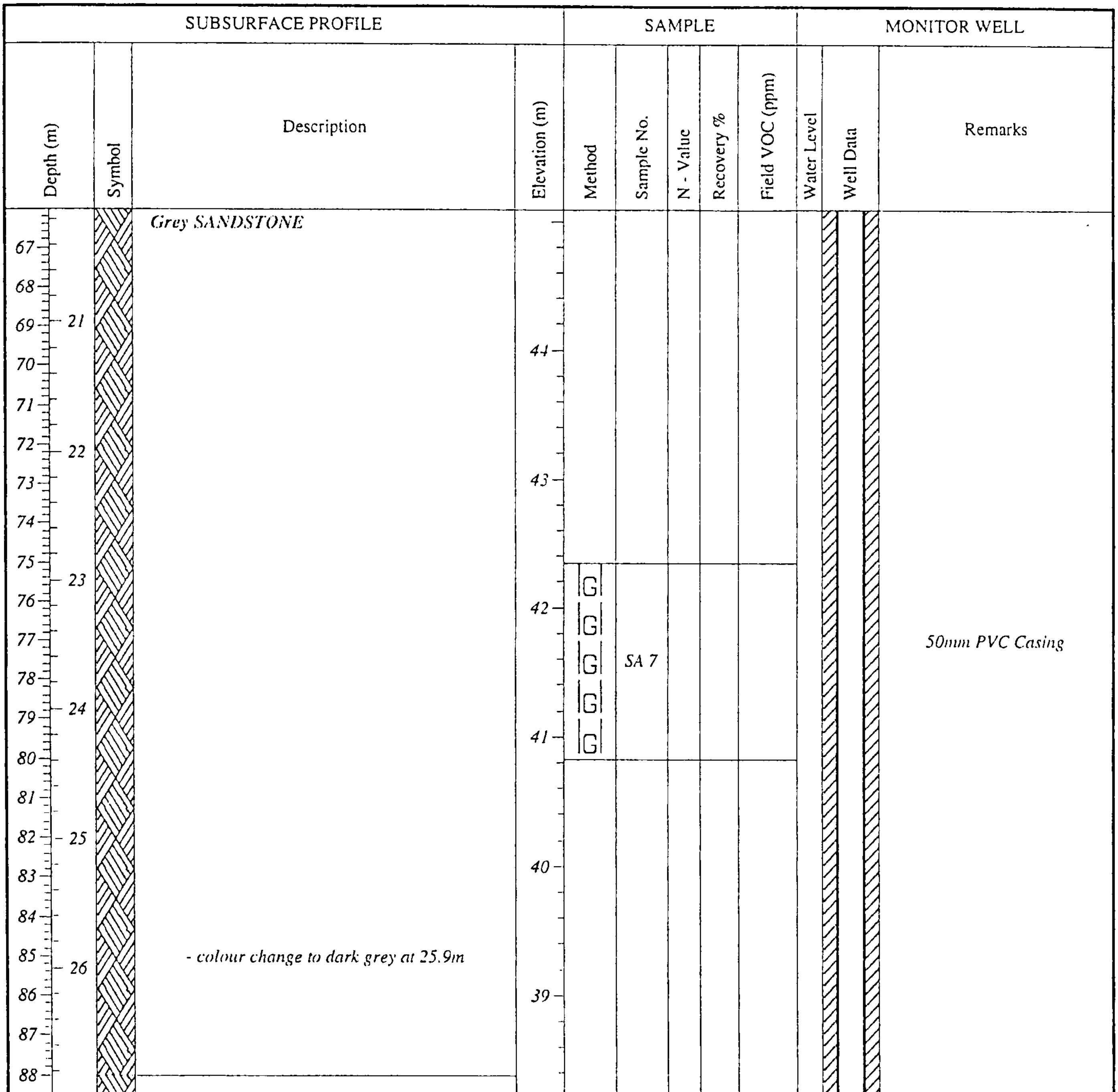
* - Submitted to Lab
SWL - Water Level
TOC - Top of Casing

Split Spoon	Clay	Fill	PVC Casing
Hollow Stem Auger	Bedrock	Sand & Gravel	Core
Grab	Silty Clay Till	Sand	PVC Screen
	Gravel	Organics	J-Plug

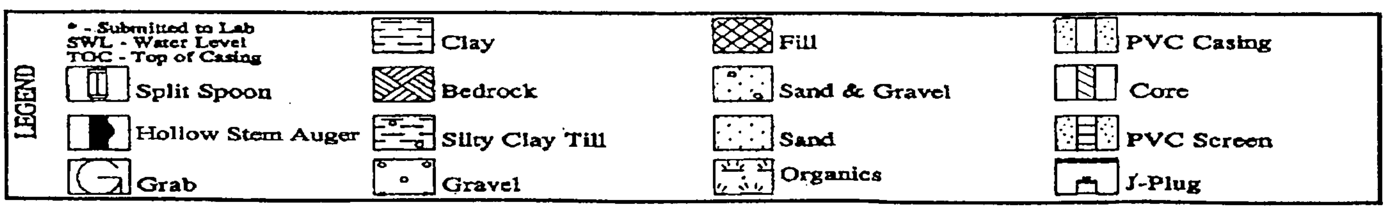
Dillon Consulting Ltd

Monitor Well: GW-GAGE-1

Project: DRDC- Explosive Residue Inv.
Project No: 02-0906-2000
Date: October 09, 2002
Location: CFB Gagetown, NB
Supervisor: JD Williams
Client: DCC Job No. GA18789



Static Water Level: 3.63 m
Ground Surface Elev: 65.21 m
Sheet: 4 of 5
Groundwater Elev: 62.24 m
Top of Casing Elev: 65.87 m

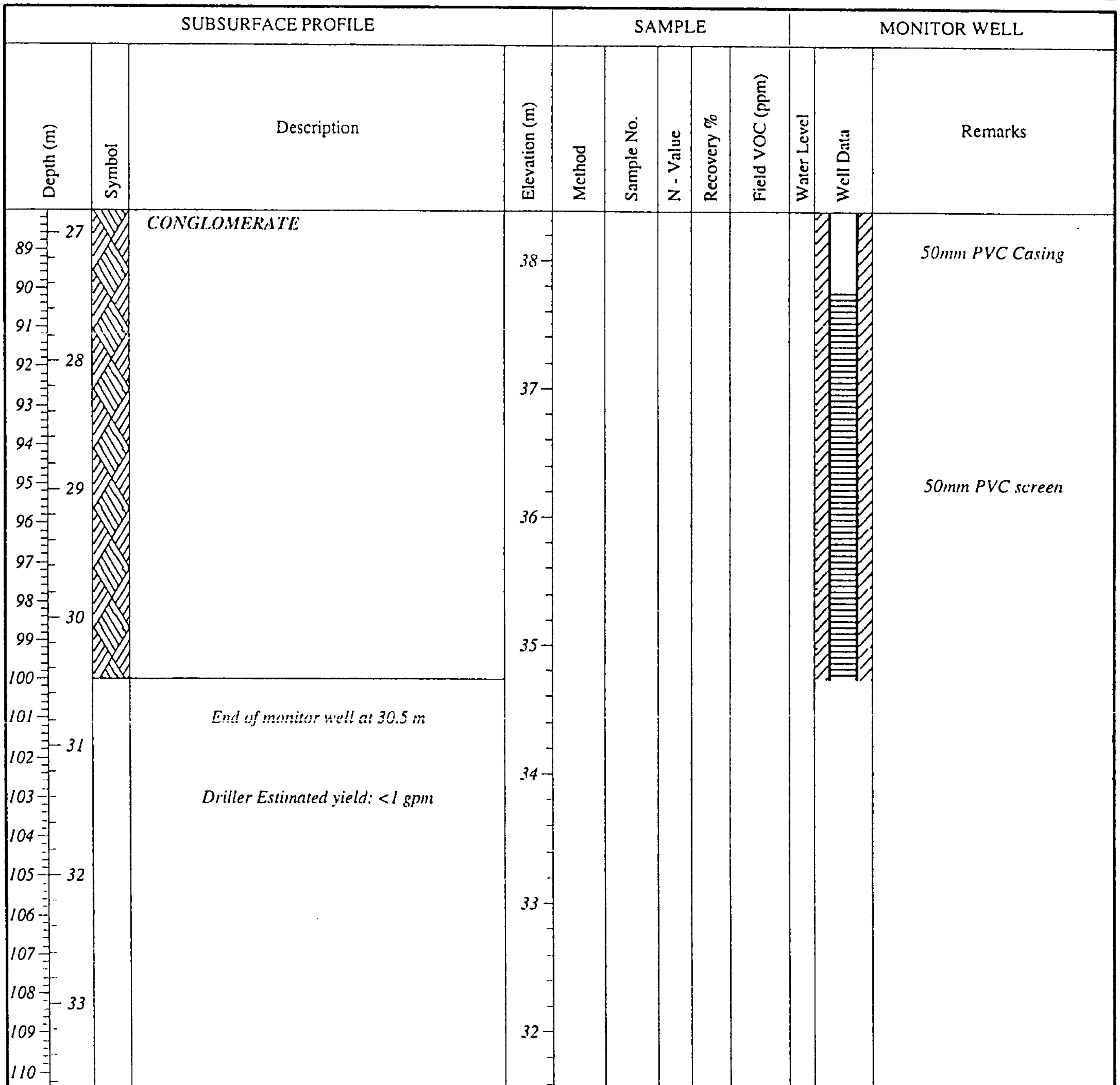


Dillon Consulting Ltd

Monitor Well: GW-GAGE-1

Project: DRDC- Explosive Residue Inv.
Project No: 02-0906-2000
Date: October 09, 2002

Location: CFB Gagetown, NB
Supervisor: JD Williams
Client: DCC Job No. GA18789



Static Water Level: 3.63 m
Ground Surface Elev: 65.21 m
Sheet: 5 of 5

Groundwater Elev: 62.24 m
Top of Casing Elev: 65.87 m

LEGEND

* - Submitted to Lab SWL - Water Level TOC - Top of Casing	Clay	Fill	PVC Casing
Split Spoon	Bedrock	Sand & Gravel	Core
Hollow Stem Auger	Silty Clay Till	Sand	PVC Screen
Grab	Gravel	Organics	J-Plug

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Dillon Consulting Ltd

Monitor Well: GW-GAGE-2

Project: DRDC- Explosive Residue Inv.
Project No: 02-0906-2000
Date: October 01, 2002

Location: CFB Gagetown, NB
Supervisor: JD Williams
Client: DCC Job No. GA18789

Depth (ft)	Depth (m)	Description	Elevation (m)	Method	Sample No.	N - Value	Recovery %	Field VOC (ppm)	Remarks
0–7	0–2	*GLACIAL TILL* Brown SILT, SAND and GRAVEL. Monitor well located at Airstrip 2 down gradient of the burn pad	59, 58						150mm dia. steel casing 0.56 m stick-up. 50mm PVC casing with 3m 0.010 slot screen installed in 150 mm dia. monitor well
7–14	2–4	*BEDROCK* Brown SANDSTONE, soft	57, 56	G	SA 1				150 mm steel casing installed to 3.7 m BGS. Bentonite grout utilized to seal casing and overburden / bedrock from surface water
14–22	4–6	Grey SILTSTONE, soft	55, 54	G	SA 2				Monitor well located at Airstrip 2 down gradient of the burn pad.

Static Water Level: 3.40 m
Groundwater Elev: 57.10 m
Ground Surface Elev: 59.91 m
Top of Casing Elev: 60.50 m
Sheet: 1 of 3

LEGEND

* - Submitted to Lab
SWL - Water Level
TOC - Top of Casing

Split Spoon, Hollow Stem Auger, Grab, Clay, Bedrock, Silty Clay Till, Gravel, Fill, Sand & Gravel, Sand, Organics, PVC Casing, Core, PVC Screen, J-Plug

Dillon Consulting Ltd

Monitor Well: GW-GAGE-2

Project: DRDC- Explosive Residue Inv. **Project No:** 02-0906-2000 **Date:** October 01, 2002

Location: CFB Gagetown, NB **Supervisor:** JD Williams **Client:** DCC Job No. GA18789

SUBSURFACE PROFILE				SAMPLE					MONITOR WELL		
Depth (m)	Symbol	Description	Elevation (m)	Method	Sample No.	N - Value	Recovery %	Field VOC (ppm)	Water Level	Well Data	Remarks
7–9 (23–30 ft)	Bedrock	*Grey SILTSTONE, soft*	53–51								
~9 (28–30 ft)			~51	G / G	SA 3						
9–14 (30–44 ft)	Bedrock	*Brown SANDSTONE*	51–47								*50mm PVC casing*
~12 (38–40 ft)			~48	G / G	SA 4						
~12 (40 ft)		*Driller noted bedrock is becoming harder at this depth*									

Static Water Level: 3.40 m Ground Surface Elev: 59.91 m Sheet: 2 of 3

Groundwater Elev: 57.10 m Top of Casing Elev: 60.50 m

LEGEND

* - Submitted to Lab
SWL - Water Level
TOC - Top of Casing

Split Spoon, Hollow Stem Auger, Grab, Clay, Bedrock, Silty Clay Till, Gravel, Fill, Sand & Gravel, Sand, Organics, PVC Casing, Core, PVC Screen, J-Plug

Dillon Consulting Ltd

Monitor Well: GW-GAGE-2

Project: DRDC- Explosive Residue Inv. **Project No:** 02-0906-2000 **Date:** October 01, 2002

Location: CFB Gagetown, NB **Supervisor:** JD Williams **Client:** DCC Job No. GA18789

SUBSURFACE PROFILE			SAMPLE			MONITOR WELL
Depth (m)	Description	Elevation (m)	Method	Sample No.	Field VOC (ppm)	Remarks
14 (46 ft)	*Brown SANDSTONE* *Driller noted -bedrock is softer at 13m - well making water at 13.7m* *-Interbedded layers of SILTSTONE and SANDSTONE to end of monitor well*	46				*50mm PVC casing*
15 (49 ft)		45				
16 (52 ft)		44				
17 (56 ft)		43				*50mm PVC screen*
18 (59 ft)		42	G G	*SA 5*		
19 (62 ft)	*End of monitor well at 18.3 m* *Drillers Estimated yield : 4-5 gpm*	41				
20 (65 ft)		40				

Static Water Level: 3.40 m
Groundwater Elev: 57.10 m
Ground Surface Elev: 59.91 m
Top of Casing Elev: 60.50 m
Sheet: 3 of 3

LEGEND

* - Submitted to Lab
SWL - Water Level
TOC - Top of Casing

Split Spoon · Hollow Stem Auger · Grab · Clay · Bedrock · Silty Clay Till · Gravel · Fill · Sand & Gravel · Sand · Organics · PVC Casing · Core · PVC Screen · J-Plug

Dillon Consulting Ltd

Monitor Well: GW-GREEN-1

Project: DRDC- Explosive Residue Inv.	**Project No:** 02-0906-2000	**Date:** October 01, 2002
Location: CFB Gagetown, NB	**Supervisor:** JD Williams	**Client:** DCC Job No. GA18789

Depth (ft)	Depth (m)	Symbol	Description	Elevation (m)	Method	Sample No.	N - Value	Recovery %	Field VOC (ppm)	Water Level	Well Data	Remarks
0–20.5	0–6.25	Sand & Gravel	*SAND and GRAVEL* Brown SILTY, SAND and GRAVEL with trace cobbles and boulders		G, G, G, G, G	SA 1						150mm dia. steel casing 0.4 m stick-up; 50mm PVC casing with 3m 0.010 slot screen installed in 150 mm dia. monitor well
17	5.2		- boulder at 5.2m BGS									
18–20					G, G	SA 2						
20.5–22	6.25–	Bedrock	*BEDROCK* Brown SANDSTONE									

Depth scale (ft): 1–22; Depth scale (m): 1, 2, 3, 4, 5, 6; Elevation scale (m): 54, 53, 52, 51, 50, 49

Static Water Level: 6.27 m	Ground Surface Elev: 54.61 m	Sheet: 1 of 3
Groundwater Elev: 48.74 m	Top of Casing Elev: 55.01 m	

LEGEND

* - Submitted to Lab
SWL - Water Level
TOC - Top of Casing

Split Spoon	Clay	Fill	PVC Casing
Hollow Stem Auger	Bedrock	Sand & Gravel	Core
Grab	Silty Clay Till	Sand	PVC Screen
	Gravel	Organics	J-Plug

Dillon Consulting Ltd

Monitor Well: GW-GREEN-1

Project: DRDC- Explosive Residue Inv. **Project No:** 02-0906-2000 **Date:** October 01, 2002

Location: CFB Gagetown, NB **Supervisor:** JD Williams **Client:** DCC Job No. GA18789

SUBSURFACE PROFILE				SAMPLE					MONITOR WELL		
Depth (m)	Symbol	Description	Elevation (m)	Method	Sample No.	N - Value	Recovery %	Field VOC (ppm)	Water Level	Well Data	Remarks
23–28 ft / 7–8 m		*BEDROCK* *Brown SANDSTONE*	48–47	G, G	*SA 3*						*150 mm steel casing installed to 7.4 m BGS. Bentonite grout utilized to seal casing and overburden / bedrock from surface water*
28–44 ft / 9–13 m		*Red SILTSTONE*	46–42	G, G	*SA 4*						*50mm PVC casing*

Depth scale (ft): 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44; (m): 7, 8, 9, 10, 11, 12, 13

Elevation scale (m): 48, 47, 46, 45, 44, 43, 42

Static Water Level: 6.27 m
Ground Surface Elev: 54.61 m
Sheet: 2 of 3

Groundwater Elev: 48.74 m
Top of Casing Elev: 55.01 m

LEGEND

* - Submitted to Lab
SWL - Water Level
TOC - Top of Casing

Split Spoon, Hollow Stem Auger, Grab, Clay, Bedrock, Silty Clay Till, Gravel, Fill, Sand & Gravel, Sand, Organics, PVC Casing, Core, PVC Screen, J-Plug

Dillon Consulting Ltd

Monitor Well: GW-GREEN-1

Project: DRDC- Explosive Residue Inv. **Project No:** 02-0906-2000 **Date:** October 01, 2002

Location: CFB Gagetown, NB **Supervisor:** JD Williams **Client:** DCC Job No. GA18789

SUBSURFACE PROFILE				SAMPLE					MONITOR WELL		
Depth (m)	Symbol	Description	Elevation (m)	Method	Sample No.	N - Value	Recovery %	Field VOC (ppm)	Water Level	Well Data	Remarks
14		Red SILTSTONE cont'd	41	G G	SA 5						50mm PVC casing
15		Greyish brown SANDSTONE medium grained - grain size decreasing with depth	40	G G	SA 6						
16–17			39–38								50mm PVC screen
18			37	G G	SA 7						
19–20		End of monitor well at 18.3 m Driller Estimated yield: 2-3 gpm	36–35								

Depth scale (ft): 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66

Static Water Level: 6.27 m
Groundwater Elev: 48.74 m
Ground Surface Elev: 54.61 m
Top of Casing Elev: 55.01 m
Sheet: 3 of 3

LEGEND

* - Submitted to Lab
SWL - Water Level
TOC - Top of Casing

Split Spoon, Hollow Stem Auger, Grab, Clay, Bedrock, Silty Clay Till, Gravel, Fill, Sand & Gravel, Sand, Organics, PVC Casing, Core, PVC Screen, J-Plug

Dillon Consulting Ltd

Monitor Well: GW-HERS-1

Project: DRDC- Explosive Residue Inv.	**Project No:** 02-0906-2000	**Date:** October 02, 2002
Location: CFB Gagetown, NB	**Supervisor:** JD Williams	**Client:** DCC Job No. GA18789

SUBSURFACE PROFILE				SAMPLE					MONITOR WELL		
Depth (m)	Symbol	Description	Elevation (m)	Method	Sample No.	N - Value	Recovery %	Field VOC (ppm)	Water Level	Well Data	Remarks
0–22 ft (0–6.7 m)		*GLACIAL TILL* Brown SILT, SAND and GRAVEL	48								*150mm dia. steel casing 0.73 m stick-up*
			47	G G G G	SA 1						*50mm PVC casing with 3m 0.010 slot screen installed in 150 mm dia. monitor well*
			46–45	G G	SA 2						
		- grain size decreasing	43–42	G G	SA 3						

Depth scale: 1–22 (ft); 1–6 (m). Elevation scale: 48–42.

Static Water Level: 2.62 m	Ground Surface Elev: 48.29 m	Sheet: 1 of 4
Groundwater Elev: 46.4 m	Top of Casing Elev: 49.02 m	

LEGEND

* - Submitted to Lab
SWL - Water Level
TOC - Top of Casing

Split Spoon	Clay	Fill	PVC Casing
Hollow Stem Auger	Bedrock	Sand & Gravel	Core
Grab	Silty Clay Till	Sand	PVC Screen
	Gravel	Organics	J-Plug

Dillon Consulting Ltd

Monitor Well: GW-HERS-1

Project: DRDC- Explosive Residue Inv. **Project No:** 02-0906-2000 **Date:** October 02, 2002

Location: CFB Gagetown, NB **Supervisor:** JD Williams **Client:** DCC Job No. GA18789

SUBSURFACE PROFILE				SAMPLE					MONITOR WELL		
Depth (m)	Symbol	Description	Elevation (m)	Method	Sample No.	N - Value	Recovery %	Field VOC (ppm)	Water Level	Well Data	Remarks
7 – 13 (23 – 44 ft)		*BEDROCK* *Conglomerate, sandstone matrix* *Groundwater noted in hole as casing being installed. This water was sealed off with the casing and bentonite grout*	41 – 35								
				G G G G	SA 4						
											50mm PVC casing

Static Water Level: 2.62 m Ground Surface Elev: 48.29 m Sheet: 2 of 4

Groundwater Elev: 46.4 m Top of Casing Elev: 49.02 m

LEGEND

* - Submitted to Lab
SWL - Water Level
TOC - Top of Casing

Split Spoon | Hollow Stem Auger | Grab | Clay | Bedrock | Silty Clay Till | Gravel | Fill | Sand & Gravel | Sand | Organics | PVC Casing | Core | PVC Screen | J-Plug

Monitor Well: GW-HERS-1

Project: DRDC- Explosive Residue Inv.
Project No: 02-0906-2000
Date: October 02, 2002
Location: CFB Gagetown, NB
Supervisor: JD Williams
Client: DCC Job No. GA18789

Depth (ft)	Depth (m)	Description	Elevation (m)	Method	Sample No.	N - Value	Recovery %	Field VOC (ppm)	Remarks
45–47	14	*BEDROCK* *Conglomerate, sandstone matrix*							*50mm PVC casing*
47–64	15–19	*Reddish brown SILTSTONE*	34	G	*SA 5*				
			33	G, G	*SA 6*				
64–66	20	*Greyish brown SANDSTONE* *fine grained*	29	G, G	*SA 7*				

Static Water Level: 2.62 m
Ground Surface Elev: 48.29 m
Sheet: 3 of 4
Groundwater Elev: 46.4 m
Top of Casing Elev: 49.02 m

LEGEND

* - Submitted to Lab
SWL - Water Level
TOC - Top of Casing

Split Spoon, Hollow Stem Auger, Grab, Clay, Bedrock, Silty Clay Till, Gravel, Fill, Sand & Gravel, Sand, Organics, PVC Casing, Core, PVC Screen, J-Plug

Dillon Consulting Ltd

Monitor Well: GW-HERS-1

Project: DRDC- Explosive Residue Inv.
Project No: 02-0906-2000
Date: October 02, 2002
Location: CFB Gagetown, NB
Supervisor: JD Williams
Client: DCC Job No. GA18789

SUBSURFACE PROFILE				SAMPLE					MONITOR WELL		
Depth (m)	Symbol	Description	Elevation (m)	Method	Sample No.	N - Value	Recovery %	Field VOC (ppm)	Water Level	Well Data	Remarks
67 ft – 68 ft		SANDSTONE cont'd	28								
68 ft – 80 ft (21 – 24.4 m)		Reddish Brown SILTSTONE		G	SA 8						
			27								
			26	G	SA 9						
			25								
			24	G	SA 10						
80 ft – 88 ft (25 – 26 m)		End of monitor well at 24.4 m									
		Driller Estimated yield: 0.5 gpm	23								
			22								

Static Water Level: 2.62 m
Ground Surface Elev: 48.29 m
Sheet: 4 of 4
Groundwater Elev: 46.4 m
Top of Casing Elev: 49.02 m

LEGEND

* - Submitted to Lab
SWL - Water Level
TOC - Top of Casing

Split Spoon, Hollow Stem Auger, Grab, Clay, Bedrock, Silty Clay Till, Gravel, Fill, Sand & Gravel, Sand, Organics, PVC Casing, Core, PVC Screen, J-Plug

Dillon Consulting Ltd

Monitor Well: GW-HERS-2

Project: DRDC- Explosive Residue Inv.
Project No: 02-0906-2000
Date: October 02, 2002

Location: CFB Gagetown, NB
Supervisor: JD Williams
Client: DCC Job No. GA18789

Depth (ft)	Depth (m)	Symbol	Description	Elevation (m)	Method	Sample No.	N - Value	Recovery %	Field VOC (ppm)	Water Level	Well Data	Remarks
0–7	0–2		*GLACIAL TILL* Brown SILT, SAND and GRAVEL									*150mm dia. steel casing 0.6 m stick-up*
				53								*50mm PVC casing with 3m 0.010 slot screen installed in 150 mm dia. monitor well*
5–6					G	SA 1						
7–10	2–3		*BEDROCK* Fine grained SANDSTONE	52	G, G	SA 2						*150 mm steel casing installed to 2.7 m BGS. Bentonite grout utilized to seal casing and overburden / bedrock from surface water*
10–22	3–6.7		*CONGLOMERATE*	51	G, G	SA 3						
	4			50								
												50mm PVC Casing
	5			49								
	6			48								

Static Water Level: 19.05 m
Ground Surface Elev: 53.94 m
Sheet: 1 of 5

Groundwater Elev: 35.49 m
Top of Casing Elev: 54.54 m

LEGEND

* - Submitted to Lab
SWL - Water Level
TOC - Top of Casing

Split Spoon · Hollow Stem Auger · Grab · Clay · Bedrock · Silty Clay Till · Gravel · Fill · Sand & Gravel · Sand · Organics · PVC Casing · Core · PVC Screen · J-Plug

Dillon Consulting Ltd

Monitor Well: GW-HERS-2

Project: DRDC- Explosive Residue Inv. **Project No:** 02-0906-2000 **Date:** October 02, 2002

Location: CFB Gagetown, NB **Supervisor:** JD Williams **Client:** DCC Job No. GA18789

SUBSURFACE PROFILE				SAMPLE					MONITOR WELL		
Depth (m)	Symbol	Description	Elevation (m)	Method	Sample No.	N - Value	Recovery %	Field VOC (ppm)	Water Level	Well Data	Remarks
23 – 7		*CONGLOMERATE*	47								
24–26		*Groundwater noted in hole as casing being installed. This water was sealed off with the casing and bentonite grout*									
26 – 8			46								
29 – 9			45								
30–32				G G	*SA 4*						*50mm PVC casing*
33 – 10			44								
36 – 11			43								
38–40			42	G G	*SA 5*						
39 – 12											
43 – 13			41								
44											

Static Water Level: 19.05 m | Ground Surface Elev: 53.94 m | Sheet: 2 of 5

Groundwater Elev: 35.49 m | Top of Casing Elev: 54.54 m

LEGEND

* - Submitted to Lab
SWL - Water Level
TOC - Top of Casing

Split Spoon	Clay	Fill	PVC Casing
Hollow Stem Auger	Bedrock	Sand & Gravel	Core
Grab	Silty Clay Till	Sand	PVC Screen
	Gravel	Organics	J-Plug

Dillon Consulting Ltd

Monitor Well: GW-HERS-2

Project: DRDC- Explosive Residue Inv. | **Project No:** 02-0906-2000 | **Date:** October 02, 2002

Location: CFB Gagetown, NB | **Supervisor:** JD Williams | **Client:** DCC Job No. GA18789

Depth (ft)	Depth (m)	Symbol	Description	Elevation (m)	Method	Sample No.	N - Value	Recovery %	Field VOC (ppm)	Water Level	Well Data	Remarks
45			*CONGLOMERATE*									
46	14			40								
47												
48												
49	15			39	G G	SA 6						
50												
51												
52	16			38								
53												
54			*Reddish brown SILTSTONE*									*50mm PVC casing*
55												
56	17			37								
57												
58												
59	18			36	G G	SA 7						
60												
61												
62	19		*Reddish brown SANDSTONE fine grained, with trace SILTSTONE fragments*	35	G G	SA 8						
63												
64												
65												
66	20			34								

Static Water Level: 19.05 m | Ground Surface Elev: 53.94 m | Sheet: 3 of 5

Groundwater Elev: 35.49 m | Top of Casing Elev: 54.54 m

LEGEND

- * - Submitted to Lab
- SWL - Water Level
- TOC - Top of Casing
- Split Spoon
- Hollow Stem Auger
- Grab
- Clay
- Bedrock
- Silty Clay Till
- Gravel
- Fill
- Sand & Gravel
- Sand
- Organics
- PVC Casing
- Core
- PVC Screen
- J-Plug

Dillon Consulting Ltd

Monitor Well: GW-HERS-2

Project: DRDC- Explosive Residue Inv.	**Project No:** 02-0906-2000	**Date:** October 02, 2002
Location: CFB Gagetown, NB	**Supervisor:** JD Williams	**Client:** DCC Job No. GA18789

SUBSURFACE PROFILE				SAMPLE					MONITOR WELL		
Depth (m)	Symbol	Description	Elevation (m)	Method	Sample No.	N - Value	Recovery %	Field VOC (ppm)	Water Level	Well Data	Remarks
67–88 ft / 21–26 m		*Reddish brown SANDSTONE fine grained, with trace SILTSTONE fragments*	33–27								*50mm PVC Casing*
~24			30	G, G	SA 9						
~26.8			27	G							

Static Water Level: 19.05 m	Ground Surface Elev: 53.94 m	Sheet: 4 of 5
Groundwater Elev: 35.49 m	Top of Casing Elev: 54.54 m	

LEGEND

* - Submitted to Lab SWL - Water Level TOC - Top of Casing	Clay	Fill	PVC Casing
Split Spoon	Bedrock	Sand & Gravel	Core
Hollow Stem Auger	Silty Clay Till	Sand	PVC Screen
Grab	Gravel	Organics	J-Plug

Dillon Consulting Ltd

Monitor Well: GW-HERS-2

Project: DRDC- Explosive Residue Inv. | Project No: 02-0906-2000 | Date: October 02, 2002

Location: CFB Gagetown, NB | Supervisor: JD Williams | Client: DCC Job No. GA18789

Depth (ft)	Depth (m)	Symbol	Description	Elevation (m)	Method	Sample No.	N - Value	Recovery %	Field VOC (ppm)	Water Level	Well Data	Remarks
89–100	27–30.5	Bedrock	*Reddish Brown SILTSTONE trace fragments of grey SILTSTONE and fine grained SANDSTONE*	26.7–23.5	G, G	SA 10					PVC Casing	*50mm PVC Casing*
											PVC Screen	*50mm PVC screen*
					G, G	SA 11						
100–110	30.5–33		*End of monitor well at 30.5 m*	23.5–20.5								
			Driller Estimated yield: <0.5 gpm									

Depth scale (ft): 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110
Depth scale (m): 27, 28, 29, 30, 31, 32, 33
Elevation scale (m): 26, 25, 24, 23, 22, 21

Static Water Level: 19.05 m | Ground Surface Elev: 53.94 m | Sheet: 5 of 5

Groundwater Elev: 35.49 m | Top of Casing Elev: 54.54 m

LEGEND

* - Submitted to Lab
SWL - Water Level
TOC - Top of Casing

Split Spoon	Clay	Fill	PVC Casing
Hollow Stem Auger	Bedrock	Sand & Gravel	Core
Grab	Silty Clay Till	Sand	PVC Screen
	Gravel	Organics	J-Plug

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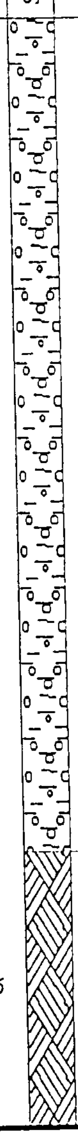
Dillon Consulting Ltd

Monitor Well: GW-LWRD-1

Project: DRDC- Explosive Residue Inv. | **Project No:** 02-0906-2000 | **Date:** October 08, 2002

Location: CFB Gagetown, NB | **Supervisor:** JD Williams | **Client:** DCC Job No. GA18789



SUBSURFACE PROFILE				SAMPLE					MONITOR WELL		
Depth (m)	Symbol	Description	Elevation (m)	Method	Sample No.	N - Value	Recovery %	Field VOC (ppm)	Water Level	Well Data	Remarks
0–5.2		*TILL* *Brown SILTY, SAND and GRAVEL with COBBLES and BOULDERS throughout.*	130–125								*150mm dia. steel casing 0.6 m stick-up* / *50mm PVC casing with 3m 0.010 slot screen installed in 150 mm dia. monitor well*
~4.5				G / G	*SA 1*						
5.2–6.6		*BEDROCK* *Grey SANDSTONE with trace brown cuttings.*	125–124								*150 mm steel casing installed to 5.5 m BGS. Bentonite grout utilized to seal casing and overburden / bedrock from surface water* / *50mm PVC Casing*

Depth scale (ft): 1–22; Depth scale (m): 1–6; Elevation scale: 129, 128, 127, 126, 125, 124.

Static Water Level: 3.67 m | Ground Surface Elev: 130.03 m | Sheet: 1 of 3

Groundwater Elev: 126.96 m | Top of Casing Elev: 130.63 m

LEGEND

* - Submitted to Lab
SWL - Water Level
TOC - Top of Casing

Split Spoon | Clay | Fill | PVC Casing
Hollow Stem Auger | Bedrock | Sand & Gravel | Core
Grab | Silty Clay Till | Sand | PVC Screen
Gravel | Organics | J-Plug

Dillon Consulting Ltd

Monitor Well: GW-LWRD-1

Project: DRDC- Explosive Residue Inv. **Project No:** 02-0906-2000 **Date:** October 08, 2002

Location: CFB Gagetown, NB **Supervisor:** JD Williams **Client:** DCC Job No. GA18789

SUBSURFACE PROFILE				SAMPLE					MONITOR WELL		
Depth (m)	Symbol	Description	Elevation (m)	Method	Sample No.	N - Value	Recovery %	Field VOC (ppm)	Water Level	Well Data	Remarks
23 ft / 7 m		*BEDROCK* Grey SANDSTONE with trace brown cuttings.	123								
25–26 ft				G	SA 2						
26 ft / 8 m			122								
29–30 ft / 9 m			121								
32 ft											50mm PVC casing
33 ft / 10 m			120								
36 ft / 11 m			119								
37–40 ft				G G G	SA 3						
39–40 ft / 12 m			118								
43 ft / 13 m			117								
44 ft											

Static Water Level: 3.67 m Ground Surface Elev: 130.03 m Sheet: 2 of 3

Groundwater Elev: 126.96 m Top of Casing Elev: 130.63 m

LEGEND

* - Submitted to Lab
SWL - Water Level
TOC - Top of Casing

Split Spoon	Clay	Fill	PVC Casing
Hollow Stem Auger	Bedrock	Sand & Gravel	Core
Grab	Silty Clay Till	Sand	PVC Screen
	Gravel	Organics	J-Plug

Dillon Consulting Ltd

Monitor Well: GW-LWRD-1

Project: DRDC- Explosive Residue Inv. | **Project No:** 02-0906-2000 | **Date:** October 08, 2002

Location: CFB Gagetown, NB | **Supervisor:** JD Williams | **Client:** DCC Job No. GA18789

Depth (ft)	Depth (m)	Description	Elevation (m)	Method	Sample No.	N - Value	Recovery %	Field VOC (ppm)	Well Data	Remarks
45–46	14	*- Black coal like mineral at 14m BGS*	116	G	SA 4					*50mm PVC casing*
49	15		115							
52	16		114							
55–56	17	*Grey SILTSTONE*	113	G	SA 5					*50mm PVC screen*
59	18		112							
61		*End of monitor well at 18.3 m*								
62–63	19	*Drillers Estimated yield : 5 gpm*	111							
65–66	20		110							

Static Water Level: 3.67 m | Ground Surface Elev: 130.03 m | Sheet: 3 of 3

Groundwater Elev: 126.96 m | Top of Casing Elev: 130.63 m

LEGEND

* - Submitted to Lab
SWL - Water Level
TOC - Top of Casing

Split Spoon; Hollow Stem Auger; Grab; Clay; Bedrock; Silty Clay Till; Gravel; Fill; Sand & Gravel; Sand; Organics; PVC Casing; Core; PVC Screen; J-Plug

Dillon Consulting Ltd

Monitor Well: GW-MCKI-1

Project: DRDC- Explosive Residue Inv.
Project No: 02-0906-2000
Date: October 07, 2002
Location: CFB Gagetown, NB
Supervisor: JD Williams
Client: DCC Job No. GA18789

SUBSURFACE PROFILE				SAMPLE					MONITOR WELL		
Depth (m)	Symbol	Description	Elevation (m)	Method	Sample No.	N - Value	Recovery %	Field VOC (ppm)	Water Level	Well Data	Remarks
0–3.9		*GLACIAL TILL* *Brown SILT, SAND and GRAVEL.*	116.61–113								*150mm dia. steel casing 0.67 m stick-up*; *50mm PVC casing with 3m 0.010 slot screen installed in 150 mm dia. monitor well*; *150 mm steel casing installed to 3.9 m BGS. Bentonite grout utilized to seal casing and overburden / bedrock from surface water*
3.9–6.7		*BEDROCK* *GREYWACKE*	113–110	G	SA 1						*50mm PVC Casing*

Depth scale: 1–22 (ft); 1–6 (m). Elevation scale: 116, 115, 114, 113, 112, 111, 110.

Static Water Level: 2.06 m
Ground Surface Elev: 116.61 m
Sheet: 1 of 2
Groundwater Elev: 115.23 m
Top of Casing Elev: 117.29 m

LEGEND

* - Submitted to Lab
SWL - Water Level
TOC - Top of Casing

Split Spoon	Clay	Fill	PVC Casing
Hollow Stem Auger	Bedrock	Sand & Gravel	Core
Grab	Silty Clay Till	Sand	PVC Screen
	Gravel	Organics	J-Plug

Dillon Consulting Ltd

Monitor Well: GW-MCKI-1

Project: DRDC- Explosive Residue Inv. | **Project No:** 02-0906-2000 | **Date:** October 07, 2002

Location: CFB Gagetown, NB | **Supervisor:** JD Williams | **Client:** DCC Job No. GA18789

Depth (ft)	Depth (m)	Symbol	Description	Elevation (m)	Method	Sample No.	N - Value	Recovery %	Field VOC (ppm)	Water Level	Well Data	Remarks
23	7	Bedrock	*BEDROCK GREYWACKE*									
24–25				109								*50mm PVC casing*
26	8											
27			*- trace quartz*									
28				108								
29–30	9		*- cuttings off white in colour*									
31–32				107								
33	10											
34–35				106	G	*SA 2*						*50mm PVC screen*
36	11											
37–38				105								
39	12				G, G	*SA 3*						
40–41			*End of monitor well at 12.2 m*	104								
42–43	13		*Drillers estimated yield : 2-3 gpm*									
44												

Static Water Level: 2.06 m | Ground Surface Elev: 116.61 m | Sheet: 2 of 2

Groundwater Elev: 115.23 m | Top of Casing Elev: 117.29 m

LEGEND

* - Submitted to Lab
SWL - Water Level
TOC - Top of Casing

Split Spoon, Hollow Stem Auger, Grab, Clay, Bedrock, Silty Clay Till, Gravel, Fill, Sand & Gravel, Sand, Organics, PVC Casing, Core, PVC Screen, J-Plug

Dillon Consulting Ltd

Monitor Well: GW-MOUNT-1

Project: DRDC- Explosive Residue Inv.	**Project No:** 02-0906-2000	**Date:** October 03, 2002
Location: CFB Gagetown, NB	**Supervisor:** JD Williams	**Client:** DCC Job No. GA18789

SUBSURFACE PROFILE				SAMPLE					MONITOR WELL		
Depth (m)	Symbol	Description	Elevation (m)	Method	Sample No.	N - Value	Recovery %	Field VOC (ppm)	Water Level	Well Data	Remarks
0–2 ft (0–0.6 m)		*FILL* *Weathered bedrock and roadway material (Sand and Gravel)*									*150mm dia. steel casing 0.83 m stick-up* *50mm PVC casing with 3m 0.010 slot screen installed in 150 mm dia. monitor well* *150 mm steel casing installed to 2.9 m BGS. Bentonite grout utilized to seal casing and overburden / bedrock from surface water*
2–22 ft		*BEDROCK* *GREWACKE*	118 – 113								
10–15 ft			116 – 115	G G G G G	SA 1						*50mm PVC Casing*
18–20 ft			114 – 113	G G	SA 2						

Depth scale: 1–22 (ft); 1–6 (m). Elevation scale: 118, 117, 116, 115, 114, 113.

Static Water Level: 1.04 m	Ground Surface Elev: 119.16 m	Sheet: 1 of 2
Groundwater Elev: 117.29 m	Top of Casing Elev: 118.33 m	

LEGEND

* - Submitted to Lab
SWL - Water Level
TOC - Top of Casing

Split Spoon	Clay	Fill	PVC Casing
Hollow Stem Auger	Bedrock	Sand & Gravel	Core
Grab	Silty Clay Till	Sand	PVC Screen
	Gravel	Organics	J-Plug

Dillon Consulting Ltd

Monitor Well: GW-MOUNT-1

Project: DRDC- Explosive Residue Inv. **Project No:** 02-0906-2000 **Date:** October 03, 2002

Location: CFB Gagetown, NB **Supervisor:** JD Williams **Client:** DCC Job No. GA18789

SUBSURFACE PROFILE				SAMPLE					MONITOR WELL		
Depth (m)	Symbol	Description	Elevation (m)	Method	Sample No.	N - Value	Recovery %	Field VOC (ppm)	Water Level	Well Data	Remarks
7 (23 ft)		*GREWACKE cont'd*	112								
8 (26 ft)			111								
9 (29 ft)			110	G G	SA 3						
10 (33 ft)			109								*50mm PVC casing*
11 (36 ft)		*Driller noted well making water at 11m*	108								
12 (39 ft)			107	G G	SA 4						
(41 ft)		*End of monitor well at 12.2 m*									
13 (43 ft)		*Estimated yield: 1-1.5 gpm*	106								

Depth scale (ft): 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44

Static Water Level: 1.04 m Ground Surface Elev: 119.16 m Sheet: 2 of 2

Groundwater Elev: 117.29 m Top of Casing Elev: 118.33 m

LEGEND

* - Submitted to Lab
SWL - Water Level
TOC - Top of Casing

Split Spoon, Hollow Stem Auger, Grab, Clay, Bedrock, Silty Clay Till, Gravel, Fill, Sand & Gravel, Sand, Organics, PVC Casing, Core, PVC Screen, J-Plug

Dillon Consulting Ltd

Monitor Well: GW-MOUNT-2

Project: DRDC- Explosive Residue Inv. **Project No:** 02-0906-2000 **Date:** October 03, 2002

Location: CFB Gagetown, NB **Supervisor:** JD Williams **Client:** DCC Job No. GA18789

Depth (m)	Symbol	Description	Elevation (m)	Method	Sample No.	N - Value	Recovery %	Field VOC (ppm)	Water Level	Well Data	Remarks
0–1 m (0–3 ft)		*FILL* *SAND and GRAVEL with weathered shale bedrock*									*150mm dia. steel casing 0.43 m stick-up* *50mm PVC casing with 3m 0.010 slot screen installed in 150 mm dia. monitor well*
1–6.7 m (3–22 ft)		*BEDROCK* *Grey SHALE*	156								*150 mm steel casing installed to 2.9 m BGS. Bentonite grout utilized to seal casing and overburden / bedrock from surface water*
				G	*SA 1*						
			155								
			154	G G	*SA 2*						
			153								*50mm PVC Casing*
			152								
			151	G G	*SA 3*						

Static Water Level: 0.60 m Ground Surface Elev: 156.99 m Sheet: 1 of 3

Groundwater Elev: 156.82 m Top of Casing Elev: 157.42 m

LEGEND

* - Submitted to Lab
SWL - Water Level
TOC - Top of Casing

Split Spoon, Hollow Stem Auger, Grab, Clay, Bedrock, Silty Clay Till, Gravel, Fill, Sand & Gravel, Sand, Organics, PVC Casing, Core, PVC Screen, J-Plug

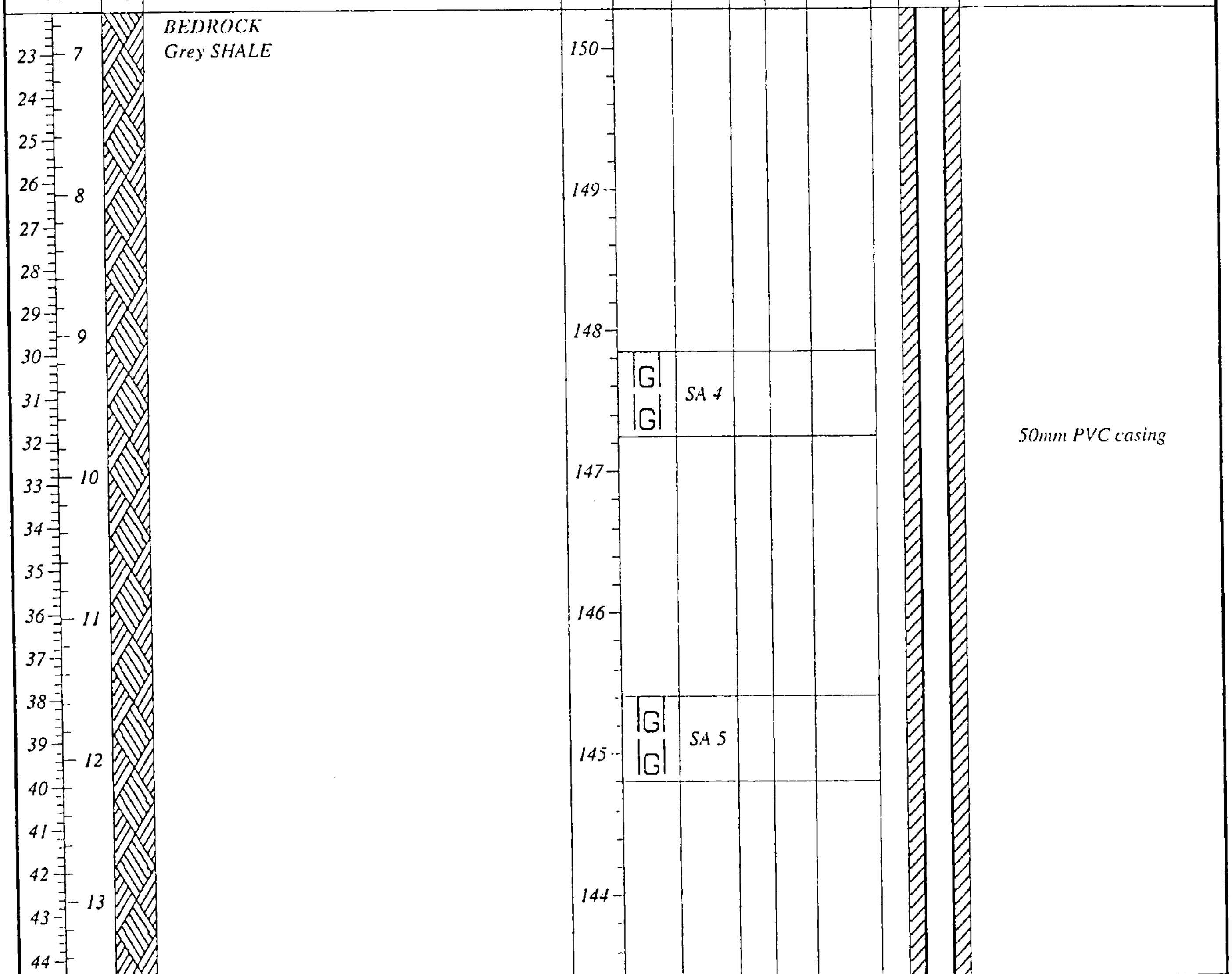
Dillon Consulting Ltd

Monitor Well: GW-MOUNT-2

Project: DRDC- Explosive Residue Inv. **Project No:** 02-0906-2000 **Date:** October 03, 2002

Location: CFB Gagetown, NB **Supervisor:** JD Williams **Client:** DCC Job No. GA18789

SUBSURFACE PROFILE				SAMPLE					MONITOR WELL		
Depth (m)	Symbol	Description	Elevation (m)	Method	Sample No.	N - Value	Recovery %	Field VOC (ppm)	Water Level	Well Data	Remarks
7 – 13		*BEDROCK* *Grey SHALE*	150 – 144								
				G G	*SA 4*						*50mm PVC casing*
				G G	*SA 5*						



Static Water Level: 0.60 m Ground Surface Elev: 156.99 m Sheet: 2 of 3

Groundwater Elev: 156.82 m Top of Casing Elev: 157.42 m

LEGEND

* - Submitted to Lab SWL - Water Level TOC - Top of Casing	Clay	Fill	PVC Casing
Split Spoon	Bedrock	Sand & Gravel	Core
Hollow Stem Auger	Silty Clay Till	Sand	PVC Screen
Grab	Gravel	Organics	J-Plug

Dillon Consulting Ltd

Monitor Well: GW-MOUNT-2

Project: DRDC- Explosive Residue Inv. **Project No:** 02-0906-2000 **Date:** October 03, 2002

Location: CFB Gagetown, NB **Supervisor:** JD Williams **Client:** DCC Job No. GA18789

SUBSURFACE PROFILE				SAMPLE					MONITOR WELL		
Depth (m)	Symbol	Description	Elevation (m)	Method	Sample No.	N - Value	Recovery %	Field VOC (ppm)	Water Level	Well Data	Remarks
45 ft – 14 m – 46 ft			143								*50mm PVC casing*
48 ft		*Intermittent brown shale strata - soft*									
49 ft – 15 m			142		*SA 6*						
52 ft – 16 m			141								
55 ft – 17 m – 56 ft			140								*50mm PVC screen*
58 ft		*Driller noted well making water at 17.7*									
59 ft – 18 m			139		*SA 7*						
61 ft		*End of monitor well at 18.3 m*									
62 ft – 19 m			138								
63 ft		*Driller Estimated yield: 6 gpm*									
65 ft – 20 m – 66 ft			137								

Static Water Level: 0.60 m Ground Surface Elev: 156.99 m Sheet: 3 of 3

Groundwater Elev: 156.82 m Top of Casing Elev: 157.42 m

LEGEND

* - Submitted to Lab
SWL - Water Level
TOC - Top of Casing

Split Spoon	Clay	Fill	PVC Casing
Hollow Stem Auger	Bedrock	Sand & Gravel	Core
Grab	Silty Clay Till	Sand	PVC Screen
	Gravel	Organics	J-Plug

Dillon Consulting Ltd

Monitor Well: GW-OPA

Project: DRDC- Explosive Residue Inv. | **Project No:** 02-0906-2000 | **Date:** October 04, 2002

Location: CFB Gagetown, NB | **Supervisor:** JD Williams | **Client:** DCC Job No. GA18789

SUBSURFACE PROFILE				SAMPLE					MONITOR WELL		
Depth (m)	Symbol	Description	Elevation (m)	Method	Sample No.	N - Value	Recovery %	Field VOC (ppm)	Water Level	Well Data	Remarks
0–22 ft (0–6.7 m)		*GLACIAL TILL* *Brown CLAYEY SILT with trace SAND and PEA GRAVEL*									*150mm dia. steel casing 0.92 m stick-up*
		Monitor well located down gradient of 'Burn Pad A' located at Observation Point Alpha	110								*50mm PVC casing with 3m 0.010 slot screen installed in 150 mm dia. monitor well*
			109								
			108								
			107								
			106	G	*SA 1*						*50mm PVC Casing*
			105								

Depth scale: 1–22 (ft) / 1–6 (m)

Static Water Level: 8.45 m | Ground Surface Elev: 111.16 m | Sheet: 1 of 5

Groundwater Elev: 103.6 m | Top of Casing Elev: 112.05 m

LEGEND

- * - Submitted to Lab
- SWL - Water Level
- TOC - Top of Casing
- Split Spoon
- Hollow Stem Auger
- Grab
- Clay
- Bedrock
- Silty Clay Till
- Gravel
- Fill
- Sand & Gravel
- Sand
- Organics
- PVC Casing
- Core
- PVC Screen
- J-Plug

Dillon Consulting Ltd

Monitor Well: GW-OPA

Project: DRDC- Explosive Residue Inv. **Project No:** 02-0906-2000 **Date:** October 04, 2002

Location: CFB Gagetown, NB **Supervisor:** JD Williams **Client:** DCC Job No. GA18789

Depth (ft)	Depth (m)	Description	Elevation (m)	Method	Sample No.	N - Value	Recovery %	Field VOC (ppm)	Water Level	Well Data	Remarks
23	7	*GLACIAL TILL cont'd*	104								
26	8		103								
29	9	*BEDROCK CONGLOMERATE*	102								*150 mm steel casing installed to 9.4 m BGS. Bentonite grout utilized to seal casing and overburden / bedrock from surface water*
33	10		101								
36	11		100								*50mm PVC casing*
38				G G	*SA 2*						
39	12		99								
42	13	*Grey SANDSTONE fine grained*	98	G	*SA 3*						
44											

Static Water Level: 8.45 m
Ground Surface Elev: 111.16 m
Sheet: 2 of 5
Groundwater Elev: 103.6 m
Top of Casing Elev: 112.05 m

LEGEND

- * - Submitted to Lab
- SWL - Water Level
- TOC - Top of Casing
- Split Spoon
- Hollow Stem Auger
- Grab
- Clay
- Bedrock
- Silty Clay Till
- Gravel
- Fill
- Sand & Gravel
- Sand
- Organics
- PVC Casing
- Core
- PVC Screen
- J-Plug

Dillon Consulting Ltd

Monitor Well: GW-OPA

Project: DRDC- Explosive Residue Inv. **Project No:** 02-0906-2000 **Date:** October 04, 2002

Location: CFB Gagetown, NB **Supervisor:** JD Williams **Client:** DCC Job No. GA18789

SUBSURFACE PROFILE				SAMPLE					MONITOR WELL		
Depth (m)	Symbol	Description	Elevation (m)	Method	Sample No.	N - Value	Recovery %	Field VOC (ppm)	Water Level	Well Data	Remarks
45–47 ft (14 m)		*Grey SANDSTONE* *fine grained*	97								
47–66 ft (14–20 m)		*Reddish brown SILTSTONE* *Cuttings are mixed with grey siltstone*	97–91								*50mm PVC casing*
58–60 ft			93	G G	*SA 4*						

Depth scale (ft): 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66

Depth scale (m): 14, 15, 16, 17, 18, 19, 20

Elevation (m): 97, 96, 95, 94, 93, 92, 91

Static Water Level: 8.45 m
Ground Surface Elev: 111.16 m
Sheet: 3 of 5

Groundwater Elev: 103.6 m
Top of Casing Elev: 112.05 m

LEGEND

* - Submitted to Lab
SWL - Water Level
TOC - Top of Casing

Split Spoon | Hollow Stem Auger | Grab | Clay | Bedrock | Silty Clay Till | Gravel | Fill | Sand & Gravel | Sand | Organics | PVC Casing | Core | PVC Screen | J-Plug

Dillon Consulting Ltd

Monitor Well: GW-OPA

Project: DRDC- Explosive Residue Inv. | **Project No:** 02-0906-2000 | **Date:** October 04, 2002

Location: CFB Gagetown, NB | **Supervisor:** JD Williams | **Client:** DCC Job No. GA18789

SUBSURFACE PROFILE				SAMPLE					MONITOR WELL		
Depth (m)	Symbol	Description	Elevation (m)	Method	Sample No.	N - Value	Recovery %	Field VOC (ppm)	Water Level	Well Data	Remarks
67 ft – 68 ft		*Reddish brown SILTSTONE* *Cuttings are mixed with grey siltstone*									
68 ft – 69 ft		*Grey SANDSTONE*									
69 ft (21 m) – 78 ft		*CONGLOMERATE*	90	G G	*SA 5*						*50mm PVC Casing*
78 ft (24 m) – 88 ft		*Grey SANDSTONE* *- From 24.4 to 25.9m BGS cuttings are a mixture of grey SANDSTONE and reddish brown SILTSTONE*	87	G G	*SA 6*						
88 ft				G							

Depth scale: 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88 (ft); 21, 22, 23, 24, 25, 26 (m)

Elevation scale: 90, 89, 88, 87, 86, 85

Static Water Level: 8.45 m | Ground Surface Elev: 111.16 m | Sheet: 4 of 5

Groundwater Elev: 103.6 m | Top of Casing Elev: 112.05 m

LEGEND

* - Submitted to Lab
SWL - Water Level
TOC - Top of Casing

Split Spoon	Clay	Fill	PVC Casing
Hollow Stem Auger	Silty Clay Till	Sand & Gravel	Core
Grab	Gravel	Sand	PVC Screen
	Bedrock	Organics	J-Plug

Dillon Consulting Ltd

Monitor Well: GW-OPA

Project: DRDC- Explosive Residue Inv. **Project No:** 02-0906-2000 **Date:** October 04, 2002

Location: CFB Gagetown, NB **Supervisor:** JD Williams **Client:** DCC Job No. GA18789

SUBSURFACE PROFILE				SAMPLE					MONITOR WELL		
Depth (m)	Symbol	Description	Elevation (m)	Method	Sample No.	N - Value	Recovery %	Field VOC (ppm)	Water Level	Well Data	Remarks
27–30.5	Bedrock	*Grey SANDSTONE* *- trace black mineral at 27.4 mBGS possibly coal fragments*	84	G	SA 7						*50mm PVC Casing*
											50mm PVC screen
			81	G	SA 8						
30.5		*End of monitor well at 30.5 m* *Driller Estimated yield: <0.5 gpm*									

Depth scale: 89–110 (ft); 27–33 (m). Elevation scale: 84–78 (m).

Static Water Level: 8.45 m

Groundwater Elev: 103.6 m

Ground Surface Elev: 111.16 m

Top of Casing Elev: 112.05 m

Sheet: 5 of 5

LEGEND

* - Submitted to Lab
SWL - Water Level
TOC - Top of Casing

Split Spoon	Clay	Fill	PVC Casing
Hollow Stem Auger	Bedrock	Sand & Gravel	Core
Grab	Silty Clay Till	Sand	PVC Screen
	Gravel	Organics	J-Plug

Dillon Consulting Ltd

Monitor Well: GW-OPLAW

Project: DRDC- Explosive Residue Inv. | **Project No:** 02-0906-2000 | **Date:** October 08, 2002

Location: CFB Gagetown, NB | **Supervisor:** JD Williams | **Client:** DCC Job No. GA18789

SUBSURFACE PROFILE				SAMPLE					MONITOR WELL		
Depth (m)	Symbol	Description	Elevation (m)	Method	Sample No.	N - Value	Recovery %	Field VOC (ppm)	Water Level	Well Data	Remarks
0–3.05 (0–10 ft)		*GLACIAL TILL* *Brown SILT, SAND and GRAVEL with trace COBBLES* *Monitor well located down gradient of burnpads adjacent building L1-2*	112, 111, 110								*150mm dia. steel casing 0.50 m stick-up* *50mm PVC casing with 3m 0.010 slot screen installed in 150 mm dia. monitor well*
3.05 (10 ft) –		*BEDROCK* *CONGLOMERATE*	109, 108, 107								*150 mm steel casing installed to 3.4 m BGS. Bentonite grout utilized to seal casing and overburden / bedrock from surface water*
18–20 ft			107–106	G G	SA 1						
– 22 ft			106								

Depth scale: feet 1–22; metres 1–6.

Static Water Level: 7.09 m | Ground Surface Elev: 111.93 m | Sheet: 1 of 2

Groundwater Elev: 4.34 m | Top of Casing Elev: 112.43 m

LEGEND

* - Submitted to Lab
SWL - Water Level
TOC - Top of Casing

Split Spoon	Bedrock	Sand & Gravel	Core
Hollow Stem Auger	Silty Clay Till	Sand	PVC Screen
Grab	Gravel	Organics	J-Plug
	Clay	Fill	PVC Casing

Dillon Consulting Ltd

Monitor Well: GW-OPLAW

Project: DRDC- Explosive Residue Inv. | **Project No:** 02-0906-2000 | **Date:** October 08, 2002

Location: CFB Gagetown, NB | **Supervisor:** JD Williams | **Client:** DCC Job No. GA18789

Depth (ft)	Depth (m)	Symbol	Description	Elevation (m)	Method	Sample No.	N - Value	Recovery %	Field VOC (ppm)	Water Level	Well Data	Remarks
23	7	Bedrock	*BEDROCK CONGLOMERATE*									
24				105								
25												
26	8											
27												
28				104								
29												
30	9											
31				103								
32												*50mm PVC casing*
33	10											
34				102								
35												
36	11											
37				101								
38					G							
39	12				G	SA 2						
40												
41			*End of monitor well at 12.2 m*	100								
42												
43	13		*Drillers estimated yield : 12 gpm*									
44				99								

Static Water Level: 7.09 m | Ground Surface Elev: 111.93 m | Sheet: 2 of 2

Groundwater Elev: 4.34 m | Top of Casing Elev: 112.43 m

LEGEND

* - Submitted to Lab
SWL - Water Level
TOC - Top of Casing

Split Spoon | Hollow Stem Auger | Grab | Clay | Bedrock | Silty Clay Till | Gravel | Fill | Sand & Gravel | Sand | Organics | PVC Casing | Core | PVC Screen | J-Plug

Dillon Consulting Ltd

Monitor Well: GW-RWS-1

Project: DRDC- Explosive Residue Inv. | **Project No:** 02-0906-2000 | **Date:** October 08, 2002

Location: CFB Gagetown, NB | **Supervisor:** JD Williams | **Client:** DCC Job No. GA18789

SUBSURFACE PROFILE				SAMPLE					MONITOR WELL		
Depth (m)	Symbol	Description	Elevation (m)	Method	Sample No.	N - Value	Recovery %	Field VOC (ppm)	Water Level	Well Data	Remarks
0–4.6	Fill	*FILL* Brown SILTY, SAND and GRAVEL with COBBLES and BOULDERS throughout. Trace wood fragments in cuttings. Possible existing/former borrow source area.	92								150mm dia. steel casing 0.92 m stick-up
				G	SA 1						50mm PVC casing with 3m 0.010 slot screen installed in 150 mm dia. monitor well
		Monitor well located down gradient of burnpad 'A'	91, 90								
		Weathered BEDROCK becoming more competent at 4.6m BGS	89								
4.6–	Bedrock	*BEDROCK* Grey SANDSTONE with trace brown cuttings.	88								150 mm steel casing installed to 5.2 m BGS. Bentonite grout utilized to seal casing and overburden / bedrock from surface water
			87	G	SA 2						50mm PVC Casing
			86								

Depth scale: 1–22 (ft); 1–6 (m).

Static Water Level: 0 m | Ground Surface Elev: 92.70 m | Sheet: 1 of 3

Groundwater Elev: 93.62 m | Top of Casing Elev: 93.62 m

LEGEND

* - Submitted to Lab
SWL - Water Level
TOC - Top of Casing

Split Spoon	Clay	Fill	PVC Casing
Hollow Stem Auger	Bedrock	Sand & Gravel	Core
Grab	Silty Clay Till	Sand	PVC Screen
	Gravel	Organics	J-Plug

Dillon Consulting Ltd

Monitor Well: GW-RWS-1

Project: DRDC- Explosive Residue Inv. **Project No:** 02-0906-2000 **Date:** October 08, 2002

Location: CFB Gagetown, NB **Supervisor:** JD Williams **Client:** DCC Job No. GA18789

SUBSURFACE PROFILE				SAMPLE					MONITOR WELL		
Depth (m)	Symbol	Description	Elevation (m)	Method	Sample No.	N - Value	Recovery %	Field VOC (ppm)	Water Level	Well Data	Remarks
23 – 7		*BEDROCK* Grey SANDSTONE with trace brown cuttings.									
24											
25			85								
26 – 8											
27											
28											
29 – 9			84	G G	SA 3						
30											
31											
32			83								*50mm PVC casing*
33 – 10											
34											
35			82								
36 – 11		- Black coal like mineral at 11.2m		G	SA 4						
37											
38			81								
39 – 12											
40											
41			80								
42 – 13		*CONGLOMERATE*									
43											
44											

Static Water Level: 0 m Ground Surface Elev: 92.70 m Sheet: 2 of 3

Groundwater Elev: 93.62 m Top of Casing Elev: 93.62 m

LEGEND

* - Submitted to Lab
SWL - Water Level
TOC - Top of Casing

Split Spoon; Hollow Stem Auger; Grab; Clay; Bedrock; Silty Clay Till; Gravel; Fill; Sand & Gravel; Sand; Organics; PVC Casing; Core; PVC Screen; J-Plug

Dillon Consulting Ltd

Monitor Well: GW-RWS-1

Project: DRDC- Explosive Residue Inv. | **Project No:** 02-0906-2000 | **Date:** October 08, 2002

Location: CFB Gagetown, NB | **Supervisor:** JD Williams | **Client:** DCC Job No. GA18789

SUBSURFACE PROFILE				SAMPLE					MONITOR WELL		
Depth (m)	Symbol	Description	Elevation (m)	Method	Sample No.	N - Value	Recovery %	Field VOC (ppm)	Water Level	Well Data	Remarks
14 (46 ft)		*Grey SANDSTONE*									*50mm PVC casing*
16.5–17 (54–56 ft)			76	G / G	*SA 5*						*50mm PVC screen*
17.7		*- At 17.7 m a cutting colour change to to brown and a significant increase in well yield noted.*	75								
18.3		*End of monitor well at 18.3 m*	74								
		Drillers estimated yield : 20+ gpm Artesian condition of approximately 4-5 gpm at top of 150 mm well casing.	73								

Depth scale: 45–66 ft / 14–20 m. Elevation scale: 79–73 m.

Static Water Level: 0 m

Groundwater Elev: 93.62 m

Ground Surface Elev: 92.70 m

Top of Casing Elev: 93.62 m

Sheet: 3 of 3

LEGEND

* - Submitted to Lab
SWL - Water Level
TOC - Top of Casing

Split Spoon	Clay	Fill	PVC Casing
Hollow Stem Auger	Bedrock	Sand & Gravel	Core
Grab	Silty Clay Till	Sand	PVC Screen
	Gravel	Organics	J-Plug

Dillon Consulting Ltd

Monitor Well: GW-RWS-1

Project: DRDC- Explosive Residue Inv.
Project No: 02-0906-2000
Date: October 08, 2002
Location: CFB Gagetown, NB
Supervisor: JD Williams
Client: DCC Job No. GA18789

SUBSURFACE PROFILE				SAMPLE					MONITOR WELL		
Depth (m)	Symbol	Description	Elevation (m)	Method	Sample No.	N - Value	Recovery %	Field VOC (ppm)	Water Level	Well Data	Remarks
0–4.5 m (0–15 ft)	Fill	*FILL* *Brown SILTY. SAND and GRAVEL with COBBLES and BOULDERS throughout. Trace wood fragments in cuttings. Possible existing/former borrow source area.* *Monitor well located down gradient of burnpad 'A'* *Weathered BEDROCK becoming more competent at 4.6m BGS*	92, 91, 90, 89	G, G	SA 1						*150mm dia. steel casing 0.92 m stick-up* *50mm PVC casing with 3m 0.010 slot screen installed in 150 mm dia. monitor well*
4.5–6.7 m (15–22 ft)	Bedrock	*BEDROCK* *Grey SANDSTONE with trace brown cuttings.*	88, 87, 86	G, G	SA 2						*150 mm steel casing installed to 5.2 m BGS. Bentonite grout utilized to seal casing and overburden / bedrock from surface water* *50mm PVC Casing*

Static Water Level: 0 m
Ground Surface Elev: 92.70 m
Sheet: 1 of 3
Groundwater Elev: 93.62 m
Top of Casing Elev: 93.62 m

LEGEND

* - Submitted to Lab
SWL - Water Level
TOC - Top of Casing

Split Spoon	Clay	Fill	PVC Casing
Hollow Stem Auger	Bedrock	Sand & Gravel	Core
Grab	Silty Clay Till	Sand	PVC Screen
	Gravel	Organics	J-Plug

Dillon Consulting Ltd

Monitor Well: GW-RWS-1

Project: DRDC- Explosive Residue Inv. **Project No:** 02-0906-2000 **Date:** October 08, 2002

Location: CFB Gagetown, NB **Supervisor:** JD Williams **Client:** DCC Job No. GA18789

SUBSURFACE PROFILE				SAMPLE					MONITOR WELL		
Depth (m)	Symbol	Description	Elevation (m)	Method	Sample No.	N - Value	Recovery %	Field VOC (ppm)	Water Level	Well Data	Remarks
7 (23 ft)		*BEDROCK* Grey *SANDSTONE with trace brown cuttings.*									
			85								
8											
9			84	G / G	*SA 3*						
10			83								*50mm PVC casing*
11		*- Black coal like mineral at 11.2m*	82	G	*SA 4*						
12			81								
13		*CONGLOMERATE*	80								

Depth scale (ft): 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44

Static Water Level: 0 m Ground Surface Elev: 92.70 m Sheet: 2 of 3

Groundwater Elev: 93.62 m Top of Casing Elev: 93.62 m

LEGEND

* - Submitted to Lab
SWL - Water Level
TOC - Top of Casing

Split Spoon, Hollow Stem Auger, Grab, Clay, Bedrock, Silty Clay Till, Gravel, Fill, Sand & Gravel, Sand, Organics, PVC Casing, Core, PVC Screen, J-Plug

Dillon Consulting Ltd

Monitor Well: GW-RWS-1

Project: DRDC- Explosive Residue Inv. **Project No:** 02-0906-2000 **Date:** October 08, 2002

Location: CFB Gagetown, NB **Supervisor:** JD Williams **Client:** DCC Job No. GA18789

SUBSURFACE PROFILE				SAMPLE						MONITOR WELL	
Depth (ft / m)	Symbol	Description	Elevation (m)	Method	Sample No.	N - Value	Recovery %	Field VOC (ppm)	Water Level	Well Data	Remarks
45–46 (14 m)			79								
46–60 (14–18 m)		Grey SANDSTONE	78, 77								50mm PVC casing
54–56			76	G, G	SA 5						50mm PVC screen
58–60		- At 17.7 m a cutting colour change to to brown and a significant increase in well yield noted.	75								
61		End of monitor well at 18.3 m	74								
63–64 (19 m)		Drillers estimated yield : 20+ gpm Artesian condition of approximately 4-5 gpm at top of 150 mm well casing.	73								
66 (20 m)											

Static Water Level: 0 m Ground Surface Elev: 92.70 m Sheet: 3 of 3

Groundwater Elev: 93.62 m Top of Casing Elev: 93.62 m

LEGEND

* - Submitted to Lab
SWL - Water Level
TOC - Top of Casing

Split Spoon | Clay | Fill | PVC Casing
Hollow Stem Auger | Bedrock | Sand & Gravel | Core
Grab | Silty Clay Till | Sand | PVC Screen
| Gravel | Organics | J-Plug

Dillon Consulting Ltd

Monitor Well: GW-YORK-1

Project: DRDC- Explosive Residue Inv.	**Project No:** 02-0906-2000	**Date:** October 03, 2002
Location: CFB Gagetown, NB	**Supervisor:** JD Williams	**Client:** DCC Job No. GA18789

SUBSURFACE PROFILE				SAMPLE					MONITOR WELL		
Depth (m)	Symbol	Description	Elevation (m)	Method	Sample No.	N - Value	Recovery %	Field VOC (ppm)	Water Level	Well Data	Remarks
0–1.2		*SILTY SAND and GRAVEL* *with weathered bedrock fragments*									*150mm dia. steel casing 0.60 m stick-up* *50mm PVC casing with 3m 0.010 slot screen installed in 150 mm dia. monitor well*
1.2–6.8		*BEDROCK* *GREWACKE with trace QUARTZ fragments*	109, 108								*150 mm steel casing installed to 1.5 m BGS. Bentonite grout utilized to seal casing and overburden / bedrock from surface water*
			107	G G	*SA 1*						
			106, 105								*50mm PVC Casing*
			104	G G	*SA 2*						

Static Water Level: 11.93 m	Ground Surface Elev: 109.90 m	Sheet: 1 of 5
Groundwater Elev: 98.36 m	Top of Casing Elev: 110.29 m	

LEGEND

* - Submitted to Lab
SWL - Water Level
TOC - Top of Casing

Split Spoon	Bedrock	Sand & Gravel	Core
Hollow Stem Auger	Silty Clay Till	Sand	PVC Screen
Grab	Gravel	Organics	J-Plug
	Clay	Fill	PVC Casing

Dillon Consulting Ltd

Monitor Well: GW-YORK-1

Project: DRDC- Explosive Residue Inv. | **Project No:** 02-0906-2000 | **Date:** October 03, 2002

Location: CFB Gagetown, NB | **Supervisor:** JD Williams | **Client:** DCC Job No. GA18789

SUBSURFACE PROFILE				SAMPLE					MONITOR WELL		
Depth (m)	Symbol	Description	Elevation (m)	Method	Sample No.	N - Value	Recovery %	Field VOC (ppm)	Water Level	Well Data	Remarks
23 ft / 7 m – 44 ft		*BEDROCK* *GREWACKE with trace QUARTZ fragments*	103								
~28–30 ft / 9 m			101	G G	SA 3						
~32–33 ft / 10 m			100								*50mm PVC casing*
~38–40 ft / 12 m			98	G G	SA 4						

Depth scale (ft): 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44; (m): 7, 8, 9, 10, 11, 12, 13

Elevation scale (m): 103, 102, 101, 100, 99, 98, 97

Static Water Level: 11.93 m | Ground Surface Elev: 109.90 m | Sheet: 2 of 5

Groundwater Elev: 98.36 m | Top of Casing Elev: 110.29 m

LEGEND

* - Submitted to Lab
SWL - Water Level
TOC - Top of Casing

Split Spoon | Hollow Stem Auger | Grab | Clay | Bedrock | Silty Clay Till | Gravel | Fill | Sand & Gravel | Sand | Organics | PVC Casing | Core | PVC Screen | J-Plug

Dillon Consulting Ltd

Monitor Well: GW-YORK-1

Project: DRDC- Explosive Residue Inv. **Project No:** 02-0906-2000 **Date:** October 03, 2002

Location: CFB Gagetown, NB **Supervisor:** JD Williams **Client:** DCC Job No. GA18789

SUBSURFACE PROFILE				SAMPLE					MONITOR WELL		
Depth (m)	Symbol	Description	Elevation (m)	Method	Sample No.	N - Value	Recovery %	Field VOC (ppm)	Water Level	Well Data	Remarks
45–66 ft / 14–20 m		*BEDROCK* *GREWACKE with trace QUARTZ fragments*	96–90								
17 m			93								*50mm PVC casing*
18 m			92	G G	*SA 5*						

Static Water Level: 11.93 m Ground Surface Elev: 109.90 m Sheet: 3 of 5

Groundwater Elev: 98.36 m Top of Casing Elev: 110.29 m

LEGEND

* - Submitted to Lab
SWL - Water Level
TOC - Top of Casing

Split Spoon	Clay	Fill	PVC Casing
Hollow Stem Auger	Bedrock	Sand & Gravel	Core
Grab	Silty Clay Till	Sand	PVC Screen
	Gravel	Organics	J-Plug

Dillon Consulting Ltd

Monitor Well: GW-YORK-1

Project: DRDC- Explosive Residue Inv. **Project No:** 02-0906-2000 **Date:** October 03, 2002

Location: CFB Gagetown, NB **Supervisor:** JD Williams **Client:** DCC Job No. GA18789

SUBSURFACE PROFILE				SAMPLE					MONITOR WELL		
Depth (m)	Symbol	Description	Elevation (m)	Method	Sample No.	N - Value	Recovery %	Field VOC (ppm)	Water Level	Well Data	Remarks
67–88 ft (21–26 m)	Bedrock	*BEDROCK* *GREWACKE with trace QUARTZ fragments*	89–83								
78–80 ft (~24 m)			86	G G	SA 6						*50mm PVC Casing*

Static Water Level: 11.93 m

Groundwater Elev: 98.36 m

Ground Surface Elev: 109.90 m

Top of Casing Elev: 110.29 m

Sheet: 4 of 5

LEGEND

* - Submitted to Lab
SWL - Water Level
TOC - Top of Casing

Split Spoon, Hollow Stem Auger, Grab, Clay, Bedrock, Silty Clay Till, Gravel, Fill, Sand & Gravel, Sand, Organics, PVC Casing, Core, PVC Screen, J-Plug

Dillon Consulting Ltd

Monitor Well: GW-YORK-1

Project: DRDC- Explosive Residue Inv. **Project No:** 02-0906-2000 **Date:** October 03, 2002

Location: CFB Gagetown, NB **Supervisor:** JD Williams **Client:** DCC Job No. GA18789

Depth (ft)	Depth (m)	Symbol	Description	Elevation (m)	Method	Sample No.	N - Value	Recovery %	Field VOC (ppm)	Water Level	Well Data	Remarks
89–90	27	Bedrock									PVC Casing	
90–92	27.6–28	Bedrock	*increased QUARTZ content noted at 27.6m*	82	G / G	SA 7					PVC Screen	
92–98	28–30	Bedrock		81							PVC Screen	*50mm PVC screen*
98–100	30–30.5	Bedrock		80	G / G	SA 8					PVC Screen	
100–110	30.5–33		*End of monitor well at 30.5 m* *Driller estimated yield: <1 gpm*	79, 78, 77								

Static Water Level: 11.93 m Ground Surface Elev: 109.90 m Sheet: 5 of 5

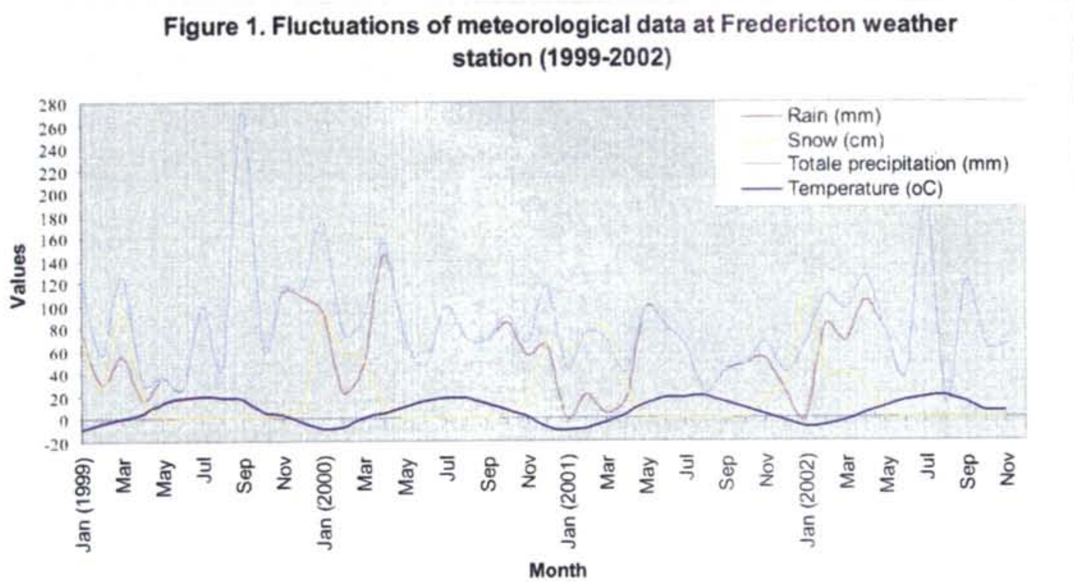
Groundwater Elev: 98.36 m Top of Casing Elev: 110.29 m

LEGEND

* - Submitted to Lab
SWL - Water Level
TOC - Top of Casing

Split Spoon | Hollow Stem Auger | Grab | Clay | Bedrock | Silty Clay Till | Gravel | Fill | Sand & Gravel | Sand | Organics | PVC Casing | Core | PVC Screen | J-Plug

Annex B – Meteorological data



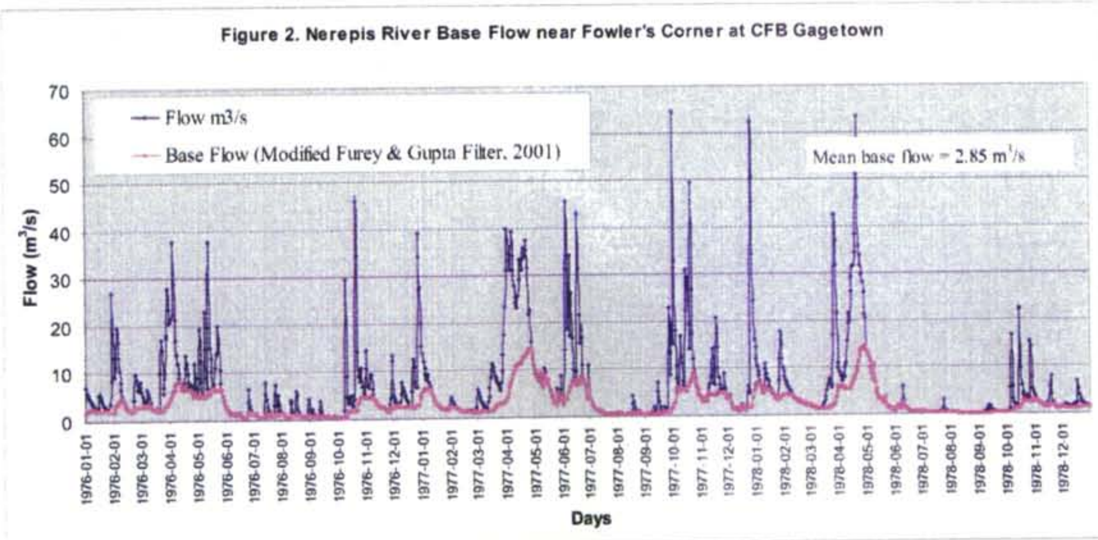


Figure 3. Piezometric variations in Royal Road Well (N.B.)

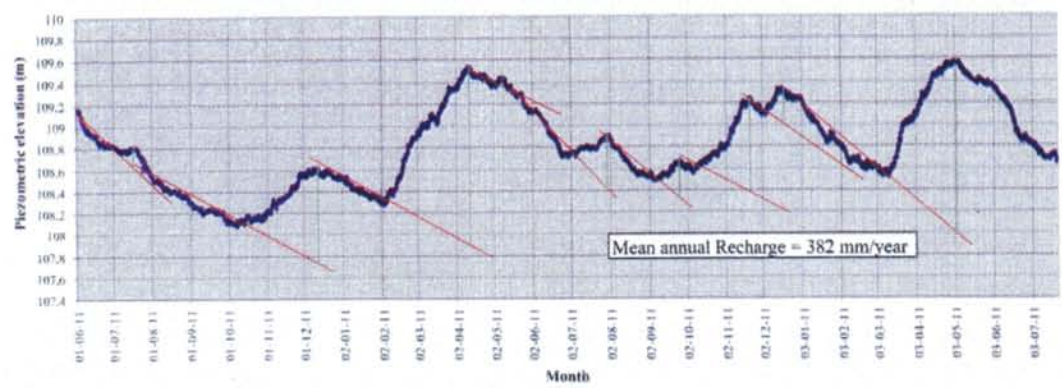
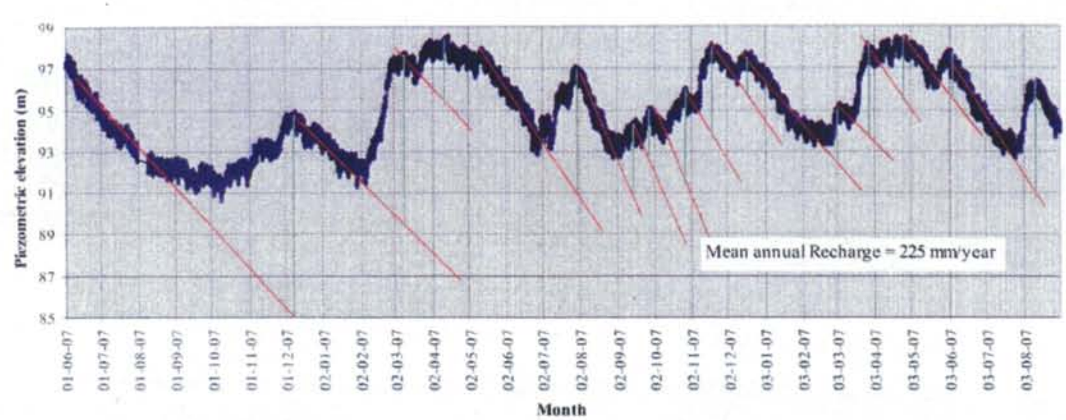


Figure 4. Piezometric Variations in New-Maryland Well (N.B.)



Annex C – Comparison of analytical results with CCME norms

CCME (Canadian Council of Ministers of the Environment) guidelines for the analysed parameters are listed as "Quality Guideline" at the top of each column. In many cases, CCME guidelines do not exist. Shaded cells indicate a parameter is above the CCME water quality guidelines for agricultural use. The values for agricultural livestock watering were used primarily, but values for agricultural irrigation were used for comparison where values for livestock watering were not established.

Wells names where analytical values are left blank indicate that the samples were destroyed in transit to the laboratory.

		Concentration of Parameter						
Well Name	Date Sampled	Zn (mg/L)	NH_4 (as N) (mg/L)	Cl (mg/L)	SO_4 (mg/L)	Nitrate & Nitrite (mg/L)	o-Phosphate (mg/L)	SiO_2 (mg/L)
		CCME Guideline Concentration for Parameter						
		50 mg/L		700 mg/L	1000 mg/L	100 mg/L		
GW-ARG-1	10/02/02	0.002	< 0.05	11.8	13	< 0.05	0.14	7.4
GW-ARG-2	10/02/02	0.004	< 0.05	2.2	6	< 0.05	< 0.01	7.4
GW-ARG-3	10/02/02	0.007	< 0.05	1.5	4	< 0.05	< 0.01	7.3
GW-ATR-1	10/09/02	0.002	< 0.05	1.9	11.9	< 0.05	0.01	8.2
GW-ATR-DUP	10/09/02	0.002	< 0.05	1.7	11.9	< 0.05	< 0.01	8.2
GW-ATR-2	10/09/02	0.005	< 0.05	1.1	9.7	< 0.05	0.01	10.6
GW-BURP-2	10/05/02	0.006	< 0.05	2.1	3	0.15	0.12	10.3
GW-BURP-4	10/05/02	0.003	< 0.05	29.0	3	< 0.05	< 0.01	11.6
GW-CASTLE-1	10/05/02	0.002	< 0.05	2.1	7	< 0.05	< 0.01	4.4
GW-CDP-1	10/02/02	0.002	< 0.05	2.1	20	< 0.05	< 0.01	6.8
GW-DRUM-1	10/05/02	0.002	< 0.05	2.6	3	< 0.05	< 0.01	4.3
GW-GRE-1	10/09/02	0.034	< 0.05	28.6	21.2	< 0.05	0.11	2.8
GW-GRE-2	10/09/02	0.002	< 0.05	2.3	24.2	< 0.05	< 0.01	12.2
GW-GREEN-5	10/02/02	0.002	< 0.05	2.1	12	< 0.05	0.05	7.9
GW-GREEN-3	10/02/02	0.002	< 0.05	1.8	4	< 0.05	0.32	8.2
GW-GREEN-4	10/02/02	0.002	< 0.05	4.8	8	< 0.05	< 0.01	10.9
GW-HANEY-1	10/05/02	0.002	< 0.05	8.6	14	< 0.05	< 0.01	7.1
GW-HANEY-2	10/05/02	0.014	< 0.05	4.8	40	< 0.05	< 0.01	1.0
GW-HANEY-DUP-2	10/05/02	0.016	< 0.05	4.9	41	< 0.05	< 0.01	1.0
GW-HANEY-3	10/05/02	0.003	< 0.05	4.9	26	< 0.05	0.01	9.6
GW-HERS-3	10/03/02	0.002	< 0.05	15.2	14	< 0.05	0.07	7.3
GW-HERS-DUP-3	10/03/02	0.001	< 0.05	15.0	14	< 0.05	0.06	7.4
GW-HERS-4	10/03/02	0.002	< 0.05	2.4	6	< 0.05	0.03	7.4
GW-LAW-1	10/08/02	0.003	< 0.05	13.9	6	0.09	< 0.01	7.1
GW-LAW-2	10/08/02	0.005	< 0.05	10.2	203	2.55	0.55	13.0
GW-LAW-3	10/26/02	0.003	< 0.05	2.2	3	0.05	0.08	8.4
GW-LAW-4	10/08/02	0.002	< 0.05	1.3	3	< 0.05	< 0.01	5.7
GW-PACK-1	10/01/02	0.005	< 0.05	9.2	4	0.91	< 0.01	7.6
GW-PACK-2	10/01/02	0.005	< 0.05	10.0	5	< 0.05	< 0.01	6.9
GW-ROCK-1	10/05/02	0.003	< 0.05	5.0	126	0.32	0.51	25.0
GW-ROCK-2	10/05/02	0.002	< 0.05	2.3	4	< 0.05	0.01	6.4
GW-ROCK-3	10/05/02	0.002	< 0.05	4.2	5	0.11	0.02	8.0
GW-ROCK-4	10/05/02	0.002	< 0.05	4.2	19	< 0.05	< 0.01	2.7
GW-BOUND-1	10/08/02	0.001	< 0.05	3.5	7	0.32	0.02	4.4
GW-BROWN-1	10/10/02	0.002	< 0.05	3.7	18.3	< 0.05	0.03	7.7
GW-BROWN-DUP	10/10/02	0.002	< 0.05	3.5	18.8	< 0.05	0.03	7.6
GW-CORN-1	10/08/02	0.002	< 0.05	2.1	3	0.07	< 0.01	6.5
GW-DING-1								
GW-ENNI-1	10/05/02	0.003	< 0.05	1.9	3	2.60	< 0.01	6.4
GW-ENNI-2	10/05/02	0.002	< 0.05	3.9	9	< 0.05	< 0.01	6.8
GW-GAGE-1	10/10/02	0.002	< 0.05	2.5	9.5	< 0.05	0.01	9.2
GW-GAGE-2								
GW-GREEN-1	10/02/02	0.002	< 0.05	1.4	5	< 0.05	< 0.01	6.5
GW-HERS-1	10/03/02	0.003	< 0.05	1.8	4	< 0.05	0.06	8.2
GW-HERS-2	10/03/02	0.003	< 0.05	3.7	10	< 0.05	0.06	7.1
GW-LWRD-1	10/08/02	0.002	< 0.05	2.5	5	< 0.05	0.03	7.8
GW-MCKI-1	10/08/02	0.003	< 0.05	2.3	6	< 0.05	< 0.01	9.1
GW-MOUNT-1	10/05/02	0.004	< 0.05	2.6	9	< 0.05	0.01	6.7
GW-MOUNT-2	10/05/02	0.006	< 0.05	2.3	4	< 0.05	< 0.01	9.9
GW-OPA	10/05/02	0.002	< 0.05	4.7	14	< 0.05	< 0.01	7.2
GW-OPLAW-1	10/09/02	0.017	< 0.05	3.1	3.2	0.92	0.01	8.5
GW-RWS-1	10/08/02	0.002	< 0.05	1.6	14	< 0.05	< 0.01	13.7
GW-BELL	10/10/02	0.002	0.09	4.0	17.6	< 0.05	0.02	9.0
GW-CLONES	10/10/02	0.005	< 0.05	10.6	1.6	< 0.05	< 0.01	11.6
GW-COOTES	10/10/02	12.8	< 0.05	1.3	39.9	< 0.05	< 0.01	6.4

Well Name	Date Sampled	Zn (mg/L)	NH$_4$ (as N) (mg/L)	Cl (mg/L)	SO$_4$ (mg/L)	Nitrate & Nitrite (mg/L)	o-Phosphate (mg/L)	SiO$_2$ (mg/L)
		Concentration of Parameter						
		CCME Guideline Concentration for Parameter						
		50 mg/L		700 mg/L	1000 mg/L	100 mg/L		
GW-HEARST								
GW-HIBERNIA	10/10/02	0.005	< 0.05	1.3	3.4	0.10	0.01	11.5
GW-HIBERNIA-DUP	10/10/02	0.005	< 0.05	1.5	3.9	0.10	< 0.01	11.5
GW-LYONS	10/09/02	0.038	< 0.05	830.0	45.9	< 0.05	< 0.01	6.1
GW-MANOR	10/10/02	0.015	< 0.05	126.0	4.1	0.05	< 0.01	5.8
GW-WORTHINGTON	10/10/02	0.106	< 0.05	2.4	23.4	< 0.05	0.02	5.8
LAWFIELD								
OLD/DOT/CP								
GW-PETERSVILLE	10/10/02	0.021	< 0.05	7.2	11.6	0.23	< 0.01	6.0
SPRINGBOK								
STH/BDY/ROAD								
DRILL WATER	10/09/02	0.034	< 0.05	38.4	8.2	1.82	< 0.01	9.0
GW-GATE16-1	10/05/02	0.021	< 0.05	4.1	12	< 0.05	< 0.01	9.8
GW-STRIP-3 (AIR STRIP-2)	10/03/02	0.002	< 0.05	2.7	3	< 0.05	0.01	12.1
GW-STRIP-DUP-2	10/03/02	0.003	< 0.05	2.2	3	< 0.05	< 0.01	12.2
GW-STRIP-3 (AIR STRIP-2)	10/03/02	0.002	< 0.05	2.7	3	< 0.05	0.01	12.1
GW-YORK-1	10/05/02	0.002	< 0.05	3.6	6	0.19	< 0.01	6.9

Well Name	Date Sampled	Al (mg/L)	Antimony (mg/L)	Arsenic (mg/L)	Barium (mg/L)	Beryllium (mg/L)	Bismuth (mg/L)	Boron (mg/L)
		Concentration of Parameter						
		CCME Guideline Concentration for Parameter						
		5 mg/L		0.1 mg/L		0.1 mg/L		5 mg/L
GW-ARG-1	10/02/02	0.04	0.0005	0.03	0.002	<0.0001	<0.001	0.032
GW-ARG-2	10/02/02	0.191	0.0005	0.002	0.048	0.0002	<0.001	0.017
GW-ARG-3	10/02/02	0.004	0.0001	<0.001	0.161	<0.0001	<0.001	0.002
GW-ATR-1	10/09/02	0.043	0.0002	0.002	0.012	<0.0001	<0.001	0.031
GW-ATR-DUP	10/09/02	0.031	0.0003	0.002	0.013	<0.0001	<0.001	0.03
GW-ATR-2	10/09/02	0.004	<0.0001	<0.001	0.122	<0.0001	<0.001	0.006
GW-BURP-2	10/05/02	0.003	0.0001	0.003	0.006	0.0001	<0.001	0.003
GW-BURP-4	10/05/02	0.025	0.0003	<0.001	0.284	0.0001	<0.001	0.01
GW-CASTLE-1	10/05/02	0.092	0.0004	0.003	0.005	0.0002	<0.001	0.02
GW-CDP-1	10/02/02	0.011	0.0001	0.004	0.011	<0.0001	<0.001	0.031
GW-DRUM-1	10/05/02	0.005	0.0001	0.001	0.072	0.0002	<0.001	0.02
GW-GRE-1	10/09/02	0.853	0.002	0.006	0.068	0.0017	<0.001	0.057
GW-GRE-2	10/09/02	0.01	0.0002	0.002	0.033	<0.0001	<0.001	0.01
GW-GREEN-5	10/02/02	0.065	0.0001	0.003	0.035	<0.0001	<0.001	0.019
GW-GREEN-3	10/02/02	0.058	0.0006	0.016	0.001	0.0001	<0.001	0.013
GW-GREEN-4	10/02/02	0.002	<0.0001	0.001	0.181	<0.0001	<0.001	0.012
GW-HANEY-1	10/05/02	0.043	0.0003	0.003	0.064	0.0001	<0.001	0.024
GW-HANEY-2	10/05/02	0.033	0.0005	<0.001	0.024	0.0002	<0.001	0.033
GW-HANEY-DUP-2	10/05/02	0.035	0.0003	<0.001	0.024	0.0002	<0.001	0.034
GW-HANEY-3	10/05/02	0.235	0.001	0.003	0.016	0.0002	<0.001	0.02
GW-HERS-3	10/03/02	0.002	0.0002	<0.001	0.034	0.0001	<0.001	0.048
GW-HERS-DUP-3	10/03/02	0.002	0.0001	<0.001	0.028	<0.0001	<0.001	0.045
GW-HERS-4	10/03/02	0.051	0.0002	0.003	0.002	<0.0001	<0.001	0.019
GW-LAW-1	10/08/02	0.015	0.0001	<0.001	0.124	<0.0001	<0.001	0.008
GW-LAW-2	10/08/02	0.079	0.0006	0.009	0.404	<0.0001	<0.001	0.054
GW-LAW-3	Oct. 26/02	0.08	<0.0001	0.003	0.015	<0.0001	<0.001	0.008
GW-LAW-4	10/08/02	0.005	<0.0001	<0.001	0.081	<0.0001	<0.001	0.007

Well Name	Date Sampled	Al (mg/L)	Antimony (mg/L)	Arsenic (mg/L)	Barium (mg/L)	Beryllium (mg/L)	Bismuth (mg/L)	Boron (mg/L)
		Concentration of Parameter						
		CCME Guideline Concentration for Parameter						
		5 mg/L		0.1 mg/L		0.1 mg/L		5 mg/L
GW-PACK-1	10/01/02	0.029	0.0002	<0.001	0.185	<0.0001	<0.001	0.009
GW-PACK-2	10/01/02	0.015	0.0002	<0.001	0.223	<0.0001	<0.001	0.014
GW-ROCK-1	10/05/02	0.176	0.0136	[redacted]	0.083	0.0002	<0.001	0.033
GW-ROCK-2	10/05/02	0.087	0.0003	<0.001	0.016	0.0002	<0.001	0.01
GW-ROCK-3	10/05/02	0.046	0.0002	0.002	0.035	0.0002	<0.001	0.007
GW-ROCK-4	10/05/02	0.023	0.0003	<0.001	0.047	0.0002	<0.001	0.035
GW-BOUND-1	10/08/02	0.035	0.0002	0.004	0.067	<0.0001	<0.001	0.015
GW-BROWN-1	10/10/02	0.303	0.0003	0.006	0.036	0.0001	<0.001	0.078
GW-BROWN-DUP	10/10/02	0.343	0.0005	0.007	0.039	<0.0001	<0.001	0.08
GW-CORN-1	10/08/02	0.004	0.0013	0.045	0.15	<0.0001	<0.001	0.002
GW-DING-1								
GW-ENNI-1	10/05/02	0.004	0.0001	<0.001	0.031	0.0001	<0.001	0.007
GW-ENNI-2	10/05/02	0.004	0.0003	0.001	0.183	0.0001	<0.001	0.007
GW-GAGE-1	10/10/02	0.006	0.0002	<0.001	0.119	<0.0001	<0.001	0.008
GW-GAGE-2								
GW-GREEN-1	10/02/02	0.031	0.0004	<0.001	0.042	<0.0001	<0.001	0.021
GW-HERS-1	10/03/02	0.055	0.0002	0.008	0.023	<0.0001	<0.001	0.021
GW-HERS-2	10/03/02	0.216	0.0013	0.015	0.01	0.0002	<0.001	0.056
GW-LWRD-1	10/08/02	0.055	0.0002	<0.001	0.026	<0.0001	<0.001	0.002
GW-MCKI-1	10/08/02	0.009	0.0002	0.001	0.158	<0.0001	<0.001	0.003
GW-MOUNT-1	10/05/02	0.072	0.0002	<0.001	0.009	0.0001	<0.001	0.001
GW-MOUNT-2	10/05/02	0.105	0.0001	<0.001	0.002	0.0002	<0.001	0.002
GW-OPA	10/05/02	0.044	0.0003	0.003	0.098	0.0002	<0.001	0.014
GW-OPLAW-1	10/09/02	0.408	0.0002	<0.001	0.072	0.0005	<0.001	0.004
GW-RWS-1	10/08/02	0.003	<0.0001	<0.001	0.082	<0.0001	<0.001	0.012
GW-YORK-1	10/05/02	0.108	0.0043	0.002	0.018	0.0002	<0.001	0.013
GW-BELL	10/10/02	0.043	0.0009	0.005	0.067	<0.0001	<0.001	0.036
GW-CLONES	10/10/02	0.088	0.0001	0.009	0.573	0.0001	<0.001	0.022
GW-COOTES	10/10/02	0.002	0.0017	0.002	0.027	<0.0001	<0.001	0.004
GW-HEARST								
GW-HIBERNIA	10/10/02	0.008	<0.0001	<0.001	0.021	<0.0001	<0.001	0.003
GW-HIBERNIA-DUP	10/10/02	0.023	<0.0001	<0.001	0.017	<0.0001	<0.001	0.004
GW-LYONS	10/09/02	0.009	0.0024	0.002	0.065	<0.0001	<0.001	0.007
GW-MANOR	10/10/02	0.03	0.0037	<0.001	0.021	<0.0001	<0.001	0.008
GW-WORTHINGTO	10/10/02	0.007	0.0098	0.012	0.042	<0.0001	<0.001	0.004
LAWFIELD								
OLD/DOT/CP								
GW-PETERSVILLE	10/10/02	0.029	0.0011	<0.001	0.101	<0.0001	<0.001	0.005
SPRINGBOK								
STH/BDY/ROA								
DRILL WATER	10/09/02	0.028	0.0032	0.007	0.031	0.0002	<0.001	0.004
GW-GATE16-1	10/05/02	0.003	0.0004	<0.001	0.112	0.0001	<0.001	0.013
GW-STRIP-3 (AIR STRIP-2)	10/03/02	0.003	0.0001	<0.001	0.247	<0.0001	<0.001	0.006
GW-STRIP-DUP-2	10/03/02	0.005	<0.0001	<0.001	0.25	0.0001	<0.001	0.007
GW-STRIP-3 (AIR STRIP-2)	10/03/02	0.003	0.0001	<0.001	0.247	<0.0001	<0.001	0.006

Well Name	Date Sampled	Chromium (mg/L)	Cobalt (mg/L)	Lead (mg/L)	Lithium (mg/L)	Magnesium (mg/L)	Mercury (mg/L)	Molybdenum (mg/L)
		Concentration of Parameter						
		CCME Guideline for Parameter						
		0.05 mg/L	0.05 mg/L	0.1 mg/L	2.5 mg/L			0.1 mg/L
GW-ARG-1	10/02/02	<0.001	0.0001	<0.0001	0.0032	0.04	<0.00005	0.0018
GW-ARG-2	10/02/02	0.001	0.0005	0.0003	0.007	0.26	<0.00005	0.0005
GW-ARG-3	10/02/02	<0.001	0.0002	0.0005	0.0009	1.24	<0.00005	0.0001
GW-ATR-1	10/09/02	0.001	<0.0001	0.0001	0.0046	0.07	<0.00005	0.0019
GW-ATR-DUP	10/09/02	<0.001	<0.0001	<0.0001	0.0047	0.07	<0.00005	0.0017
GW-ATR-2	10/09/02	<0.001	<0.0001	<0.0001	0.0021	1.83	<0.00005	0.001
GW-BURP-2	10/05/02	<0.001	<0.0001	0.0001	0.0004	0.58	<0.00005	0.0005
GW-BURP-4	10/05/02	<0.001	0.0002	0.0002	0.0078	0.84	<0.00005	0.0002
GW-CASTLE-1	10/05/02	0.001	0.0002	0.0001	0.0031	0.03	<0.00005	0.0028
GW-CDP-1	10/02/02	0.001	0.0001	<0.0001	0.0047	0.02	<0.00005	0.001
GW-DRUM-1	10/05/02	<0.001	<0.0001	<0.0001	0.0112	0.91	<0.00005	0.0007
GW-GRE-1	10/09/02	0.003	0.0023	0.0022	0.0009	0.48	<0.00005	0.0189
GW-GRE-2	10/09/02	<0.001	<0.0001	0.0002	0.0155	2.56	<0.00005	0.0261
GW-GREEN-5	10/02/02	<0.001	0.0002	0.0002	0.0022	1.04	<0.00005	0.0044
GW-GREEN-3	10/02/02	0.001	0.0002	0.0002	0.0012	0.02	<0.00005	0.0006
GW-GREEN-4	10/02/02	<0.001	<0.0001	<0.0001	0.009	3.06	<0.00005	0.0002
GW-HANEY-1	10/05/02	<0.001	0.0002	0.0001	0.0043	0.33	<0.00005	0.0026
GW-HANEY-2	10/05/02	<0.001	0.0007	0.0002	0.0033	0.1	<0.00005	0.0068
GW-HANEY-DUP-2	10/05/02	<0.001	0.0007	0.0002	0.0033	0.1	<0.00005	0.0083
GW-HANEY-3	10/05/02	<0.001	0.0017	0.0004	0.0015	2.8	<0.00005	0.0485
GW-HERS-3	10/03/02	<0.001	0.0002	<0.0001	0.0041	0.15	<0.00005	0.0034
GW-HERS-DUP-3	10/03/02	<0.001	<0.0001	<0.0001	0.0035	0.13	<0.00005	0.0032
GW-HERS-4	10/03/02	<0.001	0.0002	<0.0001	0.0028	0.02	<0.00005	0.001
GW-LAW-1	10/08/02	<0.001	0.0001	<0.0001	0.0044	2.4	<0.00005	<0.0001
GW-LAW-2	10/08/02	0.001	<0.0001	0.0002	0.0139	2.64	<0.00005	0.0317
GW-LAW-3	Oct. 26/02	<0.001	<0.0001	<0.0001	0.003	0.58	<0.00005	0.0004
GW-LAW-4	10/08/02	<0.001	0.0001	<0.0001	0.0037	0.64	<0.00005	0.0006
GW-PACK-1	10/01/02	<0.001	0.0001	<0.0001	0.0018	1	<0.00005	0.0001
GW-PACK-2	10/01/02	<0.001	0.0001	0.0002	0.0031	0.87	<0.00005	<0.0001
GW-ROCK-1	10/05/02	0.003	0.0004	0.0003	0.0057	0.51	<0.00005	0.0237
GW-ROCK-2	10/05/02	<0.001	0.0001	0.0001	0.0017	0.12	<0.00005	0.0014
GW-ROCK-3	10/05/02	<0.001	0.0001	0.0001	0.001	1.66	<0.00005	0.0007
GW-ROCK-4	10/05/02	<0.001	0.0001	<0.0001	0.0025	0.73	<0.00005	0.0034
GW-BOUND-1	10/08/02	<0.001	<0.0001	<0.0001	0.0035	0.55	<0.00005	0.0033
GW-BROWN-1	10/10/02	0.001	0.0003	0.0015	0.0262	0.11	<0.00005	0.0031
GW-BROWN-DUP	10/10/02	0.002	0.0004	0.002	0.0272	0.13	<0.00005	0.0036
GW-CORN-1	10/08/02	<0.001	<0.0001	<0.0001	0.0056	2.06	<0.00005	0.0002
GW-ENNI-1	10/05/02	0.001	<0.0001	0.0001	0.0014	9.77	<0.00005	0.0002
GW-ENNI-2	10/05/02	<0.001	0.0001	0.0001	0.0103	17.3	<0.00005	0.0006
GW-GAGE-1	10/10/02	<0.001	0.0001	<0.0001	0.007	3.17	<0.00005	
GW-GAGE-2								
GW-GREEN-1	10/02/02	<0.001	0.0002	<0.0001	0.0023	0.21	<0.00005	0.0004
GW-HERS-1	10/03/02	<0.001	0.0002	0.0001	0.0048	0.21	<0.00005	0.0007
GW-HERS-2	10/03/02	0.001	0.0004	0.0003	0.0052	0.07	<0.00005	0.0006
GW-LWRD-1	10/08/02	0.001	0.0002	<0.0001	0.0015	1.59	<0.00005	0.0001
GW-MCKI-1	10/08/02	0.001	<0.0001	<0.0001	0.0099	9.91	<0.00005	0.0002
GW-MOUNT-1	10/05/02	<0.001	0.0005	0.0002	0.0004	1.16	<0.00005	0.0004
GW-MOUNT-2	10/05/02	<0.001	0.0001	0.0002	0.0005	0.51	<0.00005	0.0003
GW-OPA	10/05/02	<0.001	0.0001	<0.0001	0.0065	1.2	<0.00005	0.0012
GW-OPLAW-1	10/09/02	0.003	0.0008	0.0009	0.0009	1.02	<0.00005	<0.0001
GW-RWS-1	10/08/02	<0.001	<0.0001	<0.0001	0.0049	2.96	<0.00005	0.0002
GW-YORK-1	10/05/02	<0.001	0.0001	0.0001	0.0088	2.3	<0.00005	0.0078
GW-BELL	10/10/02	<0.001	0.0001	0.0006	0.0044	7.84	<0.00005	0.0002
GW-CLONES	10/10/02	0.002	0.0007	0.0012	0.0494	4.41	<0.00005	0.0019
GW-COOTES	10/10/02	0.001	0.0035	0.0003	0.0017	13.2	<0.00005	0.0006
GW-HIBERNIA	10/10/02	0.001	<0.0001	0.0042	0.0003	2.65	<0.00005	<0.0001
GW-HIBERNIA-DUP	10/10/02	0.001	0.0002	0.0038	0.0003	2.53	<0.00005	<0.0001

		Concentration of Parameter						
Well Name	Date Sampled	Chromium (mg/L)	Cobalt (mg/L)	Lead (mg/L)	Lithium (mg/L)	Magnesium (mg/L)	Mercury (mg/L)	Molybdenum (mg/L)
		CCME Guideline for Parameter						
		0.05 mg/L	0.05 mg/L	0.1 mg/L	2.5 mg/L			0.1 mg/L
GW-LYONS	10/09/02	[redacted]	0.0021	0.0044	0.0099	15.4	<0.00005	0.0033
GW-MANOR	10/10/02	[redacted]	0.0005	0.0166	0.0027	0.72	<0.00005	0.0002
GW-WORTHINGTON	10/10/02	<0.001	0.0039	0.0064	0.0043	11.5	<0.00005	0.0012
LAWFIELD								
OLD/DOT/CP								
GW-PETERSVILLE	10/10/02	0.001	0.0002	0.0034	0.0101	17.2	<0.00005	0.0005
SPRINGBOK								
STH/BDY/ROAD								
DRILL WATER	10/09/02	0.002	0.0076	0.0264	0.0017	13.8	<0.00005	0.0001
GW-GATE16-1	10/05/02	<0.001	<0.0001	0.0002	0.0053	9.96	<0.00005	0.001
GW-STRIP-3 (AIR STRIP-2)	10/03/02	<0.001	0.0004	<0.0001	0.0048	2.81	<0.00005	0.0006
GW-STRIP-DUP-2	10/03/02	<0.001	0.0004	<0.0001	0.005	2.86	<0.00005	0.0005
GW-STRIP-3 (AIR STRIP-2)	10/03/02	<0.001	0.0004	<0.0001	0.0048	2.81	<0.00005	0.0006

Well Name	Date Sampled	Nickel (mg/L)	Rubidium (mg/L)	Selenium (mg/L)	Silver (mg/L)	Strontium (mg/L)	Tellurium (mg/L)	Thallium (mg/L)
		CCME Guideline for Parameter						
		0.2 mg/L		0.05 mg/L				
GW-ARG-1	10/02/02	<0.001	0.0005	0.001	<0.0001	0.02	<0.0001	<0.0001
GW-ARG-2	10/02/02	<0.001	0.0008	0.002	<0.0001	0.067	<0.0001	<0.0001
GW-ARG-3	10/02/02	<0.001	0.0004	0.002	<0.0001	0.069	<0.0001	<0.0001
GW-ATR-1	10/09/02	<0.001	0.0002	<0.001	<0.0001	0.046	<0.0001	<0.0001
GW-ATR-DUP	10/09/02	<0.001	0.0002	<0.001	<0.0001	0.047	0.0001	<0.0001
GW-ATR-2	10/09/02	<0.001	0.0004	<0.001	<0.0001	0.314	0.0001	<0.0001
GW-BURP-2	10/05/02	<0.001	0.0004	0.002	<0.0001	0.068	0.0003	<0.0001
GW-BURP-4	10/05/02	<0.001	0.0004	0.002	<0.0001	0.128	0.0003	<0.0001
GW-CASTLE-1	10/05/02	<0.001	0.0006	0.003	<0.0001	0.01	0.0004	<0.0001
GW-CDP-1	10/02/02	<0.001	0.0003	0.001	<0.0001	0.032	<0.0001	<0.0001
GW-DRUM-1	10/05/02	<0.001	0.0005	0.002	<0.0001	0.284	0.0003	<0.0001
GW-GRE-1	10/09/02	0.007	0.0022	<0.001	<0.0001	0.178	<0.0001	<0.0001
GW-GRE-2	10/09/02	<0.001	0.0007	<0.001	<0.0001	0.303	<0.0001	<0.0001
GW-GREEN-5	10/02/02	<0.001	0.0003	0.001	<0.0001	0.047	<0.0001	<0.0001
GW-GREEN-3	10/02/02	<0.001	0.0004	0.004	<0.0001	0.001	<0.0001	<0.0001
GW-GREEN-4	10/02/02	<0.001	0.0005	0.001	<0.0001	0.359	<0.0001	<0.0001
GW-HANEY-1	10/05/02	<0.001	0.0005	0.003	<0.0001	0.096	0.0003	<0.0001
GW-HANEY-2	10/05/02	0.003	0.0003	0.002	<0.0001	0.05	0.0004	<0.0001
GW-HANEY-DUP-2	10/05/02	0.003	0.0003	0.004	<0.0001	0.05	0.0004	<0.0001
GW-HANEY-3	10/05/02	0.004	0.0012	0.002	<0.0001	0.384	0.0004	<0.0001
GW-HERS-3	10/03/02	<0.001	0.0003	0.002	<0.0001	0.024	0.0001	<0.0001
GW-HERS-DUP-3	10/03/02	<0.001	0.0002	0.002	<0.0001	0.022	0.0002	<0.0001
GW-HERS-4	10/03/02	<0.001	0.0003	0.002	<0.0001	0.002	<0.0001	<0.0001
GW-LAW-1	10/08/02	<0.001	0.0006	<0.001	<0.0001	0.49	<0.0001	<0.0001
GW-LAW-2	10/08/02	<0.001	0.0012	0.006	<0.0001	1.46	<0.0001	<0.0001
GW-LAW-3	Oct. 26/02	<0.001	0.0005	0.002	<0.0001	0.064	<0.0001	<0.0001
GW-LAW-4	10/08/02	<0.001	0.0002	<0.001	<0.0001	0.126	<0.0001	<0.0001
GW-PACK-1	10/01/02	<0.001	0.0005	<0.001	<0.0001	0.226	<0.0001	<0.0001
GW-PACK-2	10/01/02	<0.001	0.0005	<0.001	<0.0001	0.303	<0.0001	<0.0001
GW-ROCK-1	10/05/02	<0.001	0.0007	0.007	<0.0001	0.18	0.0003	<0.0001

Well Name	Date Sampled	Nickel (mg/L)	Rubidium (mg/L)	Selenium (mg/L)	Silver (mg/L)	Strontium (mg/L)	Tellurium (mg/L)	Thallium (mg/L)
		Concentration of Parameter						
		CCME Guideline for Parameter						
		0.2 mg/L		0.05 mg/L				
GW-ROCK-2	10/05/02	<0.001	0.0003	0.002	<0.0001	0.025	0.0004	<0.0001
GW-ROCK-3	10/05/02	<0.001	0.0004	0.004	<0.0001	0.109	0.0003	<0.0001
GW-ROCK-4	10/05/02	<0.001	0.0004	0.004	<0.0001	0.048	0.0004	<0.0001
GW-BOUND-1	10/08/02	<0.001	0.0008	0.004	<0.0001	0.087	<0.0001	<0.0001
GW-BROWN-1	10/10/02	<0.001	0.001	<0.001	<0.0001	0.02	<0.0001	<0.0001
GW-BROWN-DUP	10/10/02	0.001	0.0011	<0.001	<0.0001	0.021	<0.0001	<0.0001
GW-CORN-1	10/08/02	<0.001	0.0011	<0.001	<0.0001	0.354	<0.0001	<0.0001
GW-DING-1								
GW-ENNI-1	10/05/02	<0.001	0.0009	0.002	<0.0001	0.139	0.0003	<0.0001
GW-ENNI-2	10/05/02	<0.001	0.0007	0.001	<0.0001	0.444	0.0002	<0.0001
GW-GAGE-1	10/10/02	<0.001	0.0011	<0.001	<0.0001	0.445	<0.0001	<0.0001
GW-GAGE-2								
GW-GREEN-1	10/02/02	<0.001	0.0005	0.001	<0.0001	0.067	<0.0001	<0.0001
GW-HERS-1	10/03/02	<0.001	0.0005	0.002	<0.0001	0.043	<0.0001	<0.0001
GW-HERS-2	10/03/02	<0.001	0.0008	0.002	<0.0001	0.009	<0.0001	<0.0001
GW-LWRD-1	10/08/02	<0.001	0.0002	<0.001	<0.0001	0.056	<0.0001	<0.0001
GW-MCKI-1	10/08/02	<0.001	0.0012	<0.001	<0.0001	0.538	<0.0001	<0.0001
GW-MOUNT-1	10/05/02	<0.001	0.0005	0.002	<0.0001	0.066	0.0003	<0.0001
GW-MOUNT-2	10/05/02	<0.001	0.0017	0.001	<0.0001	0.022	0.0002	<0.0001
GW-OPA	10/05/02	<0.001	0.0006	0.002	<0.0001	0.274	0.0004	<0.0001
GW-OPLAW-1	10/09/02	0.001	0.0009	<0.001	<0.0001	0.033	<0.0001	<0.0001
GW-RWS-1	10/08/02	<0.001	0.0003	<0.001	<0.0001	0.37	<0.0001	<0.0001
GW-YORK-1	10/05/02	<0.001	0.0038	0.003	<0.0001	0.309	0.0002	<0.0001
GW-BELL	10/10/02	<0.001	0.001	<0.001	<0.0001	0.127	<0.0001	<0.0001
GW-CLONES	10/10/02	<0.001	0.0016	<0.001	<0.0001	0.843	0.0001	<0.0001
GW-COOTES	10/10/02	0.017	0.0012	<0.001	<0.0001	0.098	<0.0001	0.0006
GW-HEARST								
GW-HIBERNIA	10/10/02	<0.001	0.0002	<0.001	<0.0001	0.093	<0.0001	<0.0001
GW-HIBERNIA-DUP	10/10/02	<0.001	0.0002	<0.001	<0.0001	0.087	<0.0001	<0.0001
GW-LYONS	10/09/02	0.177	0.0015	0.002	<0.0001	0.358	<0.0001	<0.0001
GW-MANOR	10/10/02	0.09	0.0006	<0.001	<0.0001	0.029	<0.0001	<0.0001
GW-WORTHINGTON	10/10/02	0.012	0.001	<0.001	<0.0001	0.043	<0.0001	0.0007
LAWFIELD								
OLD/DOT/CP								
GW-PETERSVILLE	10/10/02	0.001	0.0013	<0.001	<0.0001	0.218	<0.0001	<0.0001
SPRINGBOK								
STH/BDY/ROAD								
DRILL WATER	10/09/02	0.029	0.0012	0.002	<0.0001	0.099	<0.0001	0.0362
GW-GATE16-1	10/05/02	<0.001	0.0003	<0.001	<0.0001	0.622	0.0002	<0.0001
GW-STRIP-3 (AIR STRIP-2)	10/03/02	<0.001	0.0005	<0.001	<0.0001	0.323	<0.0001	<0.0001
GW-STRIP-DUP-2	10/03/02	<0.001	0.0005	0.002	<0.0001	0.319	0.0002	<0.0001
GW-STRIP-3 (AIR STRIP-2)	10/03/02	<0.001	0.0005	<0.001	<0.0001	0.323	<0.0001	<0.0001

Well Name	Date Sampled	Tin (mg/L)	Uranium (mg/L)	Vanadium (mg/L)	Cadmium (mg/L)
		Concentration of Parameter			
		CCME Guideline for Parameter			
			0.2 mg/L	0.1 mg/L	0.08 mg/L
GW-ARG-1	10/02/02	<0.0001	0.0008	0.028	<0.0005
GW-ARG-2	10/02/02	<0.0001	0.0003	0.002	<0.0005
GW-ARG-3	10/02/02	<0.0001	<0.0001	0.001	<0.0005
GW-ATR-1	10/09/02	<0.0001	<0.0001	<0.001	<0.0005
GW-ATR-DUP	10/09/02	<0.0001	<0.0001	<0.001	<0.0005
GW-ATR-2	10/09/02	<0.0001	0.0006	<0.001	<0.0005
GW-BURP-2	10/05/02	<0.0001	0.0001	0.003	<0.0005
GW-BURP-4	10/05/02	<0.0001	<0.0001	0.001	<0.0005
GW-CASTLE-1	10/05/02	<0.0001	0.0022	0.007	<0.0005
GW-CDP-1	10/02/02	<0.0001	0.0022	0.002	<0.0005
GW-DRUM-1	10/05/02	<0.0001	<0.0001	<0.001	<0.0005
GW-GRE-1	10/09/02	0.0004	0.0012	0.009	0.0008
GW-GRE-2	10/09/02	0.0003	0.0012	<0.001	<0.0005
GW-GREEN-5	10/02/02	<0.0001	0.0007	0.001	<0.0005
GW-GREEN-3	10/02/02	<0.0001	0.0002	0.035	<0.0005
GW-GREEN-4	10/02/02	<0.0001	<0.0001	<0.001	<0.0005
GW-HANEY-1	10/05/02	<0.0001	0.0029	0.003	<0.0005
GW-HANEY-2	10/05/02	0.0006	0.0014	0.001	<0.0005
GW-HANEY-DUP-2	10/05/02	0.0006	0.0013	0.001	<0.0005
GW-HANEY-3	10/05/02	0.0004	0.004	0.003	<0.0005
GW-HERS-3	10/03/02	<0.0001	<0.0001	<0.001	<0.0005
GW-HERS-DUP-3	10/03/02	<0.0001	<0.0001	0.001	<0.0005
GW-HERS-4	10/03/02	<0.0001	0.0002	0.001	<0.0005
GW-LAW-1	10/08/02	<0.0001	0.0001	<0.001	<0.0005
GW-LAW-2	10/08/02	0.0003	0.0165	0.004	<0.0005
GW-LAW-3	Oct. 26/02	0.0002	<0.0001	0.002	<0.0005
GW-LAW-4	10/08/02	<0.0001	0.0004	<0.001	<0.0005
GW-PACK-1	10/01/02	<0.0001	<0.0001	0.001	<0.0005
GW-PACK-2	10/01/02	<0.0001	0.0001	0.001	<0.0005
GW-ROCK-1	10/05/02	0.0003	0.0129	0.036	<0.0005
GW-ROCK-2	10/05/02	0.0001	0.0002	0.001	<0.0005
GW-ROCK-3	10/05/02	<0.0001	0.0004	0.002	<0.0005
GW-ROCK-4	10/05/02	<0.0001	0.0004	0.001	<0.0005
GW-BOUND-1	10/08/02	<0.0001	0.0004	<0.001	<0.0005
GW-BROWN-1	10/10/02	<0.0001	0.0003	<0.001	0.0001
GW-BROWN-DUP	10/10/02	<0.0001	0.0003	0.001	0.0001
GW-CORN-1	10/08/02	<0.0001	0.0008	0.004	<0.0005
GW-DING-1					
GW-ENNI-1	10/05/02	<0.0001	0.0002	<0.001	<0.0005
GW-ENNI-2	10/05/02	<0.0001	0.0001	<0.001	<0.0005
GW-GAGE-1	10/10/02	0.0001	0.0007	<0.001	0.0002
GW-GAGE-2					
GW-GREEN-1	10/02/02	<0.0001	<0.0001	0.002	<0.0005
GW-HERS-1	10/03/02	<0.0001	0.0003	0.004	<0.0005
GW-HERS-2	10/03/02	0.0001	0.0004	0.008	<0.0005
GW-LWRD-1	10/08/02	<0.0001	<0.0001	<0.001	<0.0005
GW-MCKI-1	10/08/02	<0.0001	0.0003	0.001	<0.0005
GW-MOUNT-1	10/05/02	<0.0001	<0.0001	0.001	<0.0005
GW-MOUNT-2	10/05/02	<0.0001	<0.0001	0.001	<0.0005
GW-OPA	10/05/02	<0.0001	0.0008	0.002	<0.0005
GW-OPLAW-1	10/09/02	<0.0001	0.0002	0.001	0.0001
GW-RWS-1	10/08/02	<0.0001	<0.0001	<0.001	<0.0005
GW-YORK-1	10/05/02	0.0022	<0.0001	0.001	<0.0005
GW-BELL	10/10/02	<0.0001	0.0006	<0.001	<0.0005
GW-CLONES	10/10/02	<0.0001	0.0197	<0.001	<0.0005
GW-COOTES	10/10/02	<0.0001	0.0026	0.001	0.0054

		Concentration of Parameter			
Well	Date	Tin	Uranium	Vanadium	Cadmium
Name	Sampled	(mg/L)	(mg/L)	(mg/L)	(mg/L)
		CCME Guideline for Parameter			
			0.2 mg/L	0.1 mg/L	0.08 mg/L
GW-PETERSVILLE	10/10/02	<0.0001	0.0006	<0.001	0.0002
SPRINGBOK					
STH/BDY/ROAD					
DRILL WATER	10/09/02	<0.0001	0.0035	0.046	[illegible]
GW-GATE16-1	10/05/02	<0.0001	0.0002	0.001	<0.0005
GW-STRIP-3 (AIR STRIP-2)	10/03/02	<0.0001	<0.0001	0.001	<0.0005
GW-STRIP-DUP-2	10/03/02	<0.0001	0.0001	0.001	<0.0005
GW-STRIP-3 (AIR STRIP-2)	10/03/02	<0.0001	<0.0001	0.001	<0.0005

		Parameter						
	Date	pH	Alkalinity	Na	K	Ca	Fe	Mn
Well Name	Sampled		(as CaCO3)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
			CCME guideline for Parameter					
		7.0-8.7				1000 mg/L	5 mg/L	0.2 mg/L
GW-GAGE-2								
GW-GREEN-1	10/02/02	7.3	42	15.7	0.50	4.34	0.02	0.024
GW-HERS-1	10/03/02	8.3	68	30.8	0.57	3.22	0.05	0.014
GW-HERS-2	10/03/02	8.9	91	46.0	0.56	0.54	0.17	0.013
GW-LWRD-1	10/08/02	6.8	23	2.25	0.78	10.3	0.06	0.040
GW-MCKI-1	10/08/02	7.3	145	4.02	0.70	39.4	< 0.02	0.046
GW-MOUNT-1	10/05/02	6.9	41	2.79	0.34	14.70	0.06	0.045
GW-MOUNT-2	10/05/02	7.1	25	2.61	0.51	8.9	0.10	0.049
GW-OPA	10/05/02	7.8	123	37.9	1.01	20.8	0.05	0.173
GW-OPLAW-1	10/09/02	7.4	11	1.92	0.53	5.82	0.35	0.136
GW-RWS-1	10/08/02	7.4	92	8.34	0.58	28.0	< 0.02	0.262
GW-YORK-1	10/05/02	7.8	35	6.30	3.64	12.6	0.04	0.046
GW-BELL	10/10/02	7.5	111	15.7	1.81	25.0	0.69	0.164
GW-CLONES	10/10/02	7.9	156	5.76	1.64	53.4	0.52	0.368
GW-COOTES	10/10/02	7.4	163	2.45	0.53	53.0	8.29	0.402
GW-HEARST								
GW-HIBERNIA	10/10/02	7.2	35	2.17	0.33	8.56	1.24	0.010
GW-HIBERNIA-DUP	10/10/02	7.4	34	2.22	0.43	7.40	1.18	0.042
GW-LYONS	10/09/02	7.7	274	509	1.34	82.0	1.02	0.034
GW-MANOR	10/10/02	7.9	165	136	0.53	19.7	7.00	0.069
GW-WORTHINGTON	10/10/02	7.5	101	1.72	0.66	28.6	2.74	0.050
LAWFIELD								
OLD/DOT/CP								
GW-PETERSVILLE	10/10/02	7.6	185	3.58	1.01	47.4	0.04	0.008
SPRINGBOK								
STH/BDY/ROAD								
DRILL WATER	10/09/02	8.6	102	15.0	0.81	42.1	0.04	0.009
GW-GATE16-1	10/05/02	7.7	107	11.0	0.23	21.0	< 0.02	< 0.001
GW-STRIP-3 (AIR STRIP-2)	10/03/02	7.2	67	3.68	0.82	21.5	0.07	[illegible]
GW-STRIP-DUP-2	10/03/02	7.3	69	3.64	0.82	21.1	0.07	[illegible]
GW-STRIP-3 (AIR STRIP-2)	10/03/02	7.2	67	3.68	0.82	21.5	0.07	0.613

Well Name	Date Sampled	pH	Alkalinity (as CaCO3)	Na (mg/L)	K (mg/L)	Ca (mg/L)	Fe (mg/L)	Mn (mg/L)
		Parameter						
			CCME guideline for Parameter					
		7.0-8.7				1000 mg/L	5 mg/L	0.2 mg/L
GW-ARG-1	10/02/02	8.9	91	53.3	0.28	1.61	0.04	0.003
GW-ARG-2	10/02/02	7.5	78	34.0	0.61	3.79	0.28	0.039
GW-ARG-3	10/02/02	7.0	17	2.18	0.57	5.37	1.25	0.119
GW-ATR-1	10/09/02	8.9	92	45.0	0.14	2.52	0.25	0.020
GW-ATR-DUP	10/09/02	8.6	92	44.6	0.14	2.57	0.10	0.019
GW-ATR-2	10/09/02	7.6	72	7.81	0.63	21.7	0.13	0.273
GW-BURP-2	10/05/02	7.4	22	4.88	0.36	5.26	< 0.02	< 0.001
GW-BURP-4	10/05/02	7.9	65	35.1	1.03	7.99	1.18	0.288
GW-CASTLE-1	10/05/02	[illegible]	133	60.7	0.30	1.07	0.30	0.006
GW-CDP-1	10/02/02	8.3	177	87.8	0.18	2.15	< 0.02	0.003
GW-DRUM-1	10/05/02	7.4	52	3.89	1.20	17.9	0.29	0.205
GW-GRE-1	10/09/02	[illegible]	120	79.8	1.08	10.7	[illegible]	0.460
GW-GRE-2	10/09/02	8.1	132	36.0	3.73	24.6	< 0.02	0.198
GW-GREEN-5	10/02/02	7.6	82	35.4	0.50	6.11	0.07	0.061
GW-GREEN-3	10/02/02	7.9	40	20.1	0.16	0.18	0.04	0.004
GW-GREEN-4	10/02/02	7.5	56	3.93	1.49	21.6	0.79	0.780
GW-HANEY-1	10/05/02	8.1	104	49.1	0.64	7.56	0.10	0.003
GW-HANEY-2	10/05/02	[illegible]	184	102	0.30	3.76	12.1	0.119
GW-HANEY-DUP-2	10/05/02	[illegible]	182	101	0.27	3.86	12.0	0.120
GW-HANEY-3	10/05/02	7.8	132	27.5	2.29	31.0	0.17	0.374
GW-HERS-3	10/03/02	[illegible]	96	56.5	0.45	2.18	0.34	0.053
GW-HERS-DUP-3	10/03/02	[illegible]	93	55.0	0.57	2.09	0.24	0.039
GW-HERS-4	10/03/02	8.1	54	27.1	0.39	0.25	0.06	0.002
GW-LAW-1	10/08/02	7.3	55	3.03	0.68	23.4	< 0.02	0.020
GW-LAW-2	10/08/02	7.5	137	64.3	1.21	77.3	0.05	0.105
GW-LAW-3	Oct. 26/02	8.0	28	10.2	0.38	4.59	0.04	0.007
GW-LAW-4	10/08/02	7.5	61	18.2	0.41	7.92	0.34	0.133
GW-PACK-1	10/01/02	[illegible]	38	11.1	0.62	11.2	0.03	0.055
GW-PACK-2	10/01/02	[illegible]	43	9.23	0.59	14.3	< 0.02	0.093
GW-ROCK-1	10/05/02	[illegible]	151	118	0.59	13.3	0.23	0.014
GW-ROCK-2	10/05/02	7.7	72	29.9	0.36	2.23	0.20	0.032
GW-ROCK-3	10/05/02	7.8	27	4.06	0.49	9.88	0.02	0.011
GW-ROCK-4	10/05/02	8.3	97	46.4	0.50	5.31	0.06	0.034
GW-BOUND-1	10/08/02	8.4	53	20.8	0.71	4.79	0.16	0.013
GW-BROWN-1	10/10/02	[illegible]	181	87.4	0.51	0.87	0.42	0.009
GW-BROWN-DUP	10/10/02	[illegible]	178	87.0	0.52	0.92	0.52	0.011
GW-CORN-1	10/08/02	[illegible]	77	2.35	0.67	26.6	< 0.02	< 0.001
GW-DING-1								
GW-ENNI-1	10/05/02	7.2	175	1.26	0.82	57.2	< 0.02	0.002
GW-ENNI-2	10/05/02	7.6	143	1.76	0.65	31.9	0.14	0.018
GW-GAGE-1	10/10/02	8.0	104	4.64	2.32	32.6	< 0.02	0.270

Distribution list

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DOCUMENT CONTROL DATA

1. ORIGINATOR (name and address)	2. SECURITY CLASSIFICATION
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The work contained in this report is a follow-up and confirmation of the data collected at CFB Gagetown during Part I of this campaign in 2001. Part I involved the sampling of 42 wells in the northern half of CFB Gagetown to characterize the underlying groundwater flow dynamics as well as the chemical characterization of the groundwater quality. This early work, which is to be found in DRDC Valcartier technical report TR 2003-016, identified a possible low-level contamination of some areas of CFB Gagetown by energetic materials. As well, seven elements in thirty-two wells were found to be higher than specified in the Canadian Council of Ministers of the Environment (CCME) guidelines.

Part II of this campaign was performed in October 2002 at CFB Gagetown, and is the focus of this report. Eighteen monitoring wells were installed, developed and sampled during Part II, largely in the southern area of the Base. In addition, 33 of the wells installed during Part I were re-sampled, and fourteen bivouac wells sampled. The data collected was used to confirm and expand the piezometric map of the aquifer underlying the Base, and to confirm and expand the analytical results of Part I.

Aluminium, manganese and iron were again found in concentrations above the CCME guidelines, confirming the findings of Part I. However, energetic materials were not detected in any of the ground or surface water samples, contrary to results from Part I. Perchlorates, which have been detected in the groundwater on American Bases, were strategically sampled in a small number of wells. Perchlorates were not detected above the detection limit of the analytical method used (500 ppb).

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Gagetown training area
Live fire range characterization
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